A Characterization and Assessment of Vessel Slip Contamination: United States Steel South Works Site and Wisconsin Steel Works Site

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EXECUTIVE SUMMARY

The purpose of this document is to perform a characterization and assessment of vessel slip contamination at the United States Steel South Works Site (USX) and the Wisconsin Steel Works Site (WSW). This assessment is in response to a petition created by the members of the South Deering Community. The petition addresses concerns of potential human health and ecological risks posed by contamination of vessel slip sediment and surface water. Due to the vast differences in available information for each site, the assessments were carried out differently.

There was insufficient information on sediment-derived contamination in the USX vessel slips. Therefore, an estimation of contaminant accumulation was calculated using existing site data. The estimation consisted of four steps, characterization of groundwater flow, determination of contaminant concentrations, calculation of loading and accumulation of contaminant in sediments. Results showed elevated levels of arsenic, beryllium, cadmium, and cyanide. The recommendation is the necessity for a greater contaminant characterization through the creation and implementation of an extensive sampling plan. Analysis of additional samples designated in the plan will determine whether remediation of the vessel slips is necessary.

An ecological and human health risk assessment was carried out on the WSW vessel slips to evaluate the likelihood of adverse effects associated with contaminants in sediments and surface water. The framework for the risk assessments included a problem formulation phase, an exposure and effects phase, and a final risk characterization phase.

The ecological risk assessment included measurements of sediment and surface water chemistry, toxicity testing, tissue residue analyses, and macroinvertebrate community structure. Sediment chemistry data showed elevated levels of PAHs, metals, and PCBs. Surface water data showed levels of aluminium, cadmium, and lead above Ambient Water Quality Standards (AWQS). The West End of the South Vessel Slip was found to be acutely toxic to fish. Fish tissue samples contained chemical concentrations above Tissue Screening Concentrations (TSCs), indicating potential adverse toxicological effect in fish. The vessel slips' benthic community was characterized as scarce, with pollutant tolerant organisms (aquatic worms of *oligochaeta*) as the dominant species. Thus, the recommendation is for remediation of the vessel slips through dredging.

The human health risk assessment quantified the magnitude, frequency and duration of direct and indirect exposure of anglers to COCs from the vessel slips. Exposure routes consisted of ingestion of contaminated fish and dermal contact with contaminated surface water during fishing activities. Results illustrated that the carcinogenic and noncarcinogenic risks to anglers exposed to vessel slip surface waters or contaminated fish were insignificant.

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ACRONYMS

USACE: U.S. Army Corps of Engineers

AET: apparent effects threshold

ARCS: Assessment and Remediation of Contaminated Sediments

AST: aboveground storage tank

BSAF: biota-sediment accumulation factor

CERCLA: Comprehensive Environmental Response, Compensation and Liability Act of 1980

COC: contaminant of concern

D.O.: dissolved oxygen

EDA: Economic Development Administration of the US Department of Commerce

EPA: United States Environmental Protection Agency

ER-L: effects range-low value

ER-M: effects range-median value

FI: fraction of intake

HI: hazard index

HPAH: high molecular weight PAH

HQ: hazard quotient

IEPA: Illinois Environmental Protection Agency

IR: ingestion rate

IRIS: Integrated Risk Information System

LEL: lowest effect level

LPAH:	low molecular weight PAH
MOE:	Ministry of the Environment
Navistar:	Navistar International Transportation Corporation
NEL:	no effect level
NOAA:	National Oceanic and Atmospheric Administration
NSQS:	National Sediment Quality Survey
PAH:	polynuclear aromatic hydrocarbon
PC:	permeability constant
PCB:	polychlorinated biphenyls
Phase I:	Phase I Remedial Investigation
Phase II:	Phase II Remedial Investigation
Phase III:	Phase III Remedial Investigation
RA:	Risk Assessment
RBC:	Risk Based Concentration
RfD:	reference dose
SEL:	severe effect level
SF:	slope factor
SVOC:	semi-volatile organic compound
TBP:	theoretical bioaccumulation potential
TOC:	total organic carbon
TPH:	total petroleum hydrocarbons
TSC:	Tissue Screening Concentration
USEPA:	(refer to EPA acronym)

USFWS:	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UST:	underground storage tank
USX:	United States Steel
VOC:	volatile organic compounds
WSW:	Wisconsin Steel Works

1.0 Introduction

There have been vast changes in the communities of southeastern Chicago over the past century. At the turn of the 19^{th} century through the middle of the 20^{th} century there was a boom of industrial growth in the area. Many steel making facilities were built and operated during this period. The byproduct contaminants of these steelmaking processes also began to leach out of the facilities and became deposited on the surrounding land. Production increased until the mid 1960s when demand began to languish. The facilities began to decrease production and shut down processes through the latter half of the 20^{th} century. By the mid eighties many of the facilities were closed down completely and most of the standing buildings demolished. Though there were no remnants of industry visible on the land the contaminants produced were still present in the ground.

As a result of the jobs provided by the industry, communities of steelworkers and their families grew up around the facilities. In recent years many members of the surrounding communities have become concerned with the human health and ecological implications of residual contamination. The pollution on two sites in particular has been questioned. Those facilities are the United States Steel South Works Site and the Wisconsin Steel Works Site.

1.1 Current State of Affairs

Although remediation activities have been carried out at both properties, they have purposely excluded the vessel slips. A No Further Remediation letter was issued to USX indicating that they had remediated the South Works Site to the level of Residential and Industrial use. However, both vessel slips were excluded in the letter. As a result, no remediation work has been done in the USX vessel slips. Only a very limited assessment of chemicals present in the sediments of the vessel slips has been carried out.

Geraghty & Miller was contracted by Navistar to carry out an Ecological Risk Assessment. This report evaluated the potential for adverse effects in the vessel slips as a result of sediment-derived contaminants. The conclusion of the report was that vessel slip contamination did not pose a hazard and therefore, no remediation was required. However, these recommendations contradicted the conclusions arrived at by another independent agency. The US Fish & Wildlife Service (USFWS) carried out an independent ecological study on the state of the Calumet River and WSW vessel slips. The USFWS concluded that the sediments in both vessel slips be remediated as they had a potential to cause adverse ecological effects on the environment of the Calumet River. As they express, "remediation of the barge slip sediments will lessen the local risk to aquatic and wildlife species." (USFWS, 1994).

The United States Army Corps of Engineers (USACE) is dredging the Calumet River during the year 2000. The agency has offered to dredge the slips of the facilities for a small cost. Both USX and WSW have declined this offer.

The community is concerned with the human health and ecological risks posed by contaminants associated with the production of steel present in both the sediments and surface waters of the sites' vessel slips. In addition, they feel that addressing contaminated sediments in the slips is key in the restoration of the quality of the Calumet River.

A petition has been drafted by community groups under the authority given by CERCLA Section 9605(a) of Title 42 of the United States Code. This title gives the right for any person or group that is affected by a release or threatened release of contaminants to petition the President of the United States for a preliminary assessment performed by the USEPA. An advanced copy of the petition has been given to the USEPA and USX Corporation. The final submission is set for June 15, 2000. The petitioners have requested to utilize Northwestern University resources to carry out an independent preliminary assessment of the vessel slips. Results will be used to assess the need for remediation and as a means of comparison to the requested USEPA assessment.

1.2 Objective

The purpose of this document is to provide an independent characterization and assessment of contamination in the vessel slip sediments of both the USX and WSW sites. Other studies have aimed to characterize the contamination in the soil and groundwater of the site, but none have addressed the vessel slips in particular. The report will assess the need for remediation of the vessel slips as addressed by the South Deering Community.

Due to the dissimilarity in information available for each site, different methods were used for assessment of each site. Due to the lack of information at USX an estimation of vessel slip contamination has been performed. This estimation was carried out using site information including groundwater flow, concentration of contaminants in groundwater and sedimentation in the vessel slips. This evaluation has allowed for the calculation of the theoretical concentration of contaminants on a mass by mass basis. The data available for WSW is more extensive therefore; an ecological and human health risk assessment has been executed. The ecological risk assessment used sediment contaminant concentrations, toxicity tests, tissue residue assessment and macroinvertebrate community structure. The human health risk assessment used risks associated with ingestion of contaminated fish and dermal contact with surface water.

1.3 Contaminant Effects

There is a concern about the concentration of chemicals because there are known adverse effects that accompany elevated levels. A summary of each contaminant's properties includes fate, transport and physiological effects to ecology and humans.

Heavy Metals

Heavy metals generally dissolve readily in water and though the compounds may change from one form to another they do not break down (Env. Defense, 2000). They persists in the environmental and bioaccumulate in tissues. Heavy metals include arsenic, beryllium, cadmium and lead.

Arsenic

This heavy metal is a known carcinogen that affects human physiology in a number of different ways. At high levels, damage to the liver, skin, stomach and intestines occur. Direct contact at lower doses may result in swelling and redness of the skin. Ingestion at low doses may cause nausea, vomiting, redness and inflammation, kidney damage, diarrhea, abnormal heart rhythm, blood vessel damage, decreased production of red and white blood cells, shock, coma, convulsions or death. Chronic doses affect the skin through, increased pigmentation, rashes; the muscles through paralyses and atrophy; organs through visual disturbances, cirrhosis of the liver and kidneys; and overall body through fatigue or hypertension (Env. Defense, 2000).

Beryllium

Exposure to low levels of this known carcinogen may lead to the development of hypersensitivity. Individuals who suffer from this impairment develop an inflammatory reaction to low doses of beryllium compounds. The resulting reaction is named Chronic Beryllium Disease and may result in difficulty breathing, weakness and fatigue or death. Contact with great of enough levels of beryllium may cause rashes or ulcers on the skin (Env. Defense, 2000).

Beryllium compounds are slightly soluble in water, but generally settle out as particulate matter. Therefore, it does not collect much in the tissues of fish or other aquatic organisms (Env. Defense, 2000).

Cadmium

This heavy metal has been determined to be a carcinogen. Exposure to high levels may cause vomiting, diarrhea, irritation of the stomach and increased salivation. Cadmium tends to build up in the kidneys and cause kidney disease when an organism is exposed to lower levels for long periods of time (Env. Defense, 2000).

Cadmium is slightly soluble in water, but binds well to soil particles. Due to the stability of its compounds it remains in the body for extended periods of time and collects in the tissues of exposed organisms (Env. Defense, 2000).

Lead

Lead has an affinity for soil particles and remains in soil or water for a long time without degrading. Lead is absorbed mostly through the gastrointestinal tract. The absorbed lead migrates to the liver and kidneys before it is deposited in the bones. Most damage is caused to the liver, kidneys, male gonads, heart, and immune system. Young and unborn children are most susceptible to the effects of heightened levels of lead. Exposure of children to lead may cause learning and behavioral difficulties, decrease mental ability and growth reduction.

Manganese

In humans, affects the central nervous system (noncarcinogenic).

Vanadium

Exposure to this metal causes gastrointestinal tract disturbances, papular skin rash and possibly teratogenic and mutagenic affects.

Chloroform

In humans, affects the kidney and liver (carcinogenic).

Cyanide

In humans, affects the central nervous system (noncarcinogenic).

Methylene Chloride

In humans, affects the liver (carcinogenic). In humans, affects the lung (carcinogenic).

Phenol

In humans, affects the reproductive system by ingestion only (noncarcinogenic).

PAHs

Polynuclear aromatic hydrocarbons (PAHs) are compounds containing one or more aromatic rings. They are characterized as nonpolar compounds, having a low aqueous solubility. PAHs are classified as hydrophobic or "water-hating" chemicals. PAHs are often divided into two groups according to their molecular weight. The low molecular weight PAHs (or LPAHs) contain 2-3 fused rings, whereas the high molecular PAHs (HPAHs) contain 4 -6 fused rings. The aqueous solubility of PAHs decreases as the number of aromatic rings (and thus molecular weight) increases. Naphthalene is amongst the smallest molecular weight PAHs containing 2 fused aromatic rings. Naphthalene has a solubility of 30 ppm. In contrast, PAHs containing 5 and more aromatic rings have drastically smaller solubilities in the range of 0.5-5.0 ppb. Thus LPAHs tend to be more soluble in water than HPAHs and as a result are more bioavailable to aquatic organisms.

Due to their hydrophobic nature, PAHs tend to sorb onto particulate matter such as organic particles suspended in surface water or present in sediments. PAHs also tend to partition to lipids contained in tissue of aquatic organisms. The characteristic lipid-water partitioning coefficient of PAHs strongly favors the rapid transfer of PAHs from the aqueous phase into lipid rich tissue (Rand, 1985). Thus aquatic organisms are able to accumulate PAHs present at even low concentrations in the aqueous phase, food or sediment. In humans the buildup of PAHs has carcinogenic affects on the gastrointestinal system.

PCBs

Polychlorinated biphenyls (PCBs) Aroclors are characterized as having low aqueous phase solubility. Less chlorinated PCBs tend to be more soluble in water than highly chlorinated PCBs and partition more quickly from sediments to surficial waters (Rand, 1985). Less chlorinated PCBs are therefore more bioavailable to aquatic organisms than heavily chlorinated ones. PCBs are also highly resistant to environmental degradation and therefore persist in the environment for extended periods of time.

PCBs are highly lipophilic compounds and thus fish and invertebrates have the potential to accumulate concentrations greater than those found in the surrounding surface water. The uptake of PCBs takes place directly from surface water or through ingestion of contaminated food and sediments. Since PCBs are lipophilic and resistant to breakdown, these compounds can biomagnify as they move up the food chain (Hooper *et al.*, 1989). Impact of PCBs can therefore occur at every level of the food web.

2.0 USX Problem Formulation

2.1 Site Characterization

2.1.1 Site History

The United States Steel South Works Site (USX) is situated on 567 acres of land on the southeast side of Chicago located between East 79th and East 91st Streets. It is bordered by Lake Michigan on the north and east, on the west by a residential area and on the south by the Calumet River. It contains two vessel slips, one leading to Lake Michigan, the North Slip, and the other leading to the Calumet River, the South Slip. The dimensions of the North Slip are 2745 feet in length and 180 feet in width. The South Slip is 1230 feet long and the width ranges from 60 feet at the north end to 300 feet at the south end. The North Slip splits the site into northern and southern sections. Using this division, the North Slip is contiguous to the North Ore Yard and the South Slip to the South Ore Yard. When the plant was in operation the slips were used for the shipping and receiving of materials. See Figure 2-1, where the vessel slips have been highlighted in blue.

The USX site was constructed under the jurisdiction of the North Chicago Railway Mill Company beginning in March of 1880. The original size of the site was 73 acres, which included the South Vessel Slip only. Steel production began at the site in 1882 under the ownership and operation of the Illinois Steel Company, which later became the Carnegie-Illinois Steel Company. In 1901 the South Works site became part of United States Steel, a sub-unit of USX Corporation. The site produced billets, structural beams, rods, plates and alloy bars. All raw materials and coke were imported from off-site locations. From the period of 1901 to 1944 the site expanded to include 567 acres, which was obtained by filling in areas of Lake Michigan with molten slag (a byproduct of operations), brick, concrete and refractory materials from onsite demolition. Peak production of steel was reached in 1951 equaling 3.75 million tons of steel; after which shipments began to decline. By 1982 only 2 operations, an electric furnace and a beam mill, were still in operation. Between 1982 and 1991 two-thirds of the site facilities

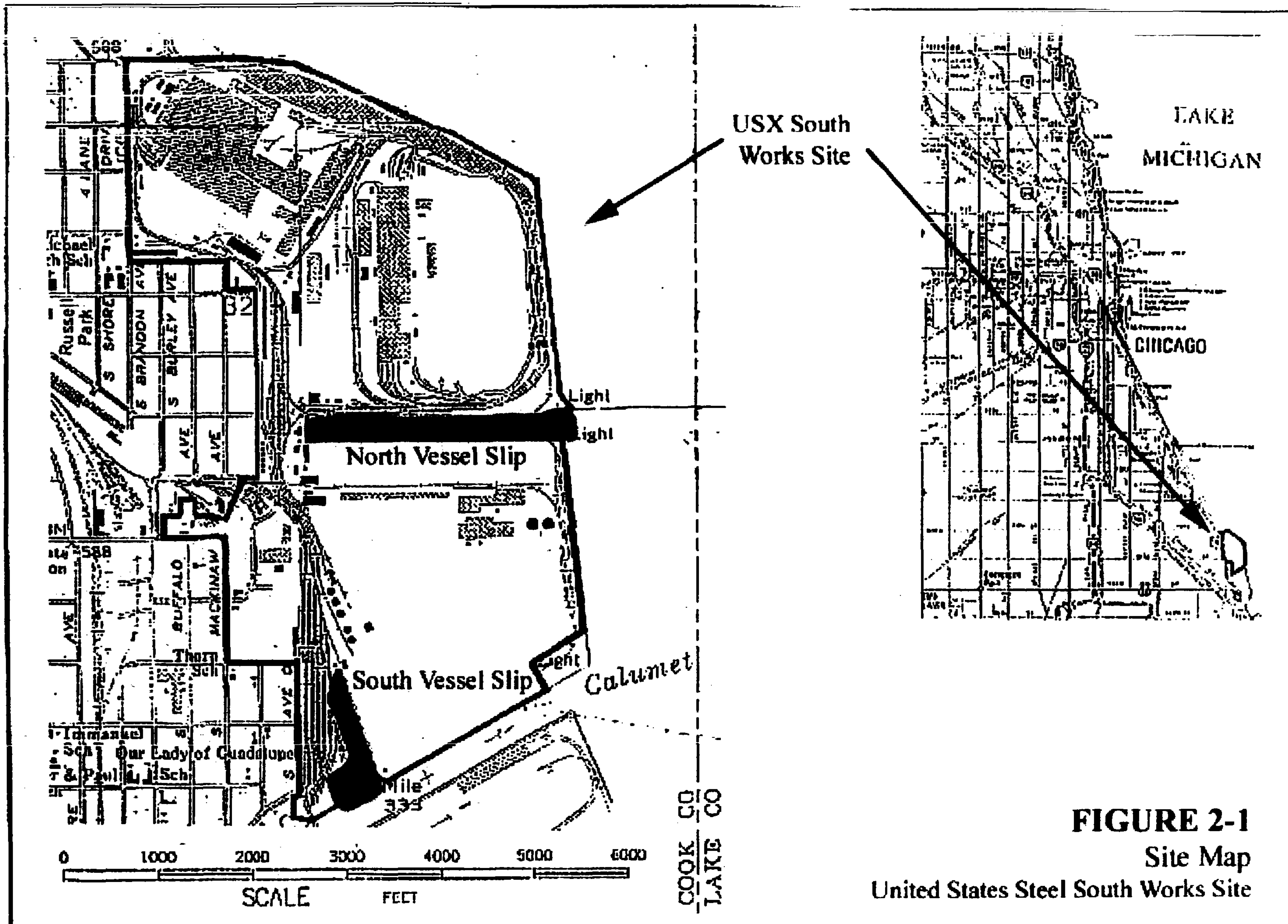


FIGURE 2-1
Site Map
United States Steel South Works Site

Source: Bongiovanni et al., 1997

were torn down. Remaining site operations were shut down in April of 1992. In December of 1993 the USX South works site was entered into the Illinois Environmental Protection Agency's (IEPA) Voluntary Pre-Notice Site Cleanup Program. In July of 1997 IEPA issued a No Further Remediation letter to USX for the South Works Site. This letter detailed that USX "had completed its responsibilities in remediating the South Works Site for residential or industrial use." Several areas were excluded from this No Further Remediation Letter including the North and South Vessel Slips (Draft Petition, 1999).

It has been determined that groundwater is mounded in two areas of the site. One mass is located between the northern border of the site and the North Slip. The other high area is placed between the North Slip and the Calumet River on the southern half of the site. Groundwater from both these mounds flows radially outward to the North and South Vessel Slips, Lake Michigan and the Calumet River (Bongiovanni et al. 1997).

Most of the site is composed of slag fill, which is heterogeneous in nature. At the site the slag layer varies up to a depth of 35 feet (WTI, 1994). The origin of the slag used on the site has not been reliably identified. The slag may have been produced from the on-site electric furnace or imported from an off-site blast furnace. The majority of slag used for industrial purposes has been blast furnace slag. Therefore, the composition of blast furnace slag has been used as reference for this report. This material, although varied in composition, is able to withstand large loads. It is rather unaffected by changes imposed by freezing and thawing that may cause problems with building foundations. Even when placed along waterways, as in this case, it is very resistant to erosion. These properties are made possible by the fusion of the particles in the material, which form a porous yet strong mass (Josephson, 1949).

2.1.2 Past Site Activities

The South Vessel Slip was last dredged in 1974. Five thousand cubic yards were removed and placed in an on-site containment facility. The permit was approved in July 1974 and the completion report issued in July 1976. Approval was given on the knowledge that USX implement a water quality monitoring program. The monitoring program was to extend from 1 week before dredging to 4 weeks following its completion.

As part of the Voluntary Pre-Notice Site Cleanup Program USX was required to devise and carry out site remediation goals. The goals and implementation are contained in the remediation report. Described therein is an explanation of the activities performed to clean up the site. These activities included remediation of the soil and groundwater on the site to allowable levels. Because they were not included in the Site Cleanup Plan there were no efforts made to remediate the vessel slips. The remediation goals contained in the plan clearly excluded the vessel slips from any remediation activities. The vessel slips were also not included in the No Further Remediation letter from the IEPA to USX after successful completion of the remediation plan.

2.1.3 Previous Investigations

There have been several previous studies and assessments of the USX South Works Site; however, most do not incorporate the vessel slips. Waste Technologies, Inc. (WTI), as retained by USX, prepared Phase I, II and III reports on the site between February 1993 and September 1994. The Phase I studied the type and extent of contamination of the site, migration of contaminants and exposure pathways to humans and the environment. This was performed by analysis of samples from 26 soil borings, 17 groundwater monitoring wells and sediment from sewers and manholes. Inventory was taken of the locations of USTs, ASTs, drums, and railroad ties. Low levels of cyanide, TPH, heavy metals, VOCs and SVOCs were found. The Phase II analyzed additional groundwater samples, soil samples from additional locations, and sediment samples from manholes and subsurface pits. The sampling stations were analyzed based on information gained in the Phase I investigation. Low levels of cyanide and heavy metals were identified. The Phase III included the installation of 3 deep monitoring wells and soil borings laid out on a grid system. Samples were taken from groundwater monitoring wells, soil borings, and vessel slips sediments. A total of 48 soil samples were analyzed and 20 groundwater samples. The sampling of vessel slip sediments was performed at the request of the IEPA. A total of 5 samples were taken, 3 from the North

Slip and 2 from the South Slip. Heavy metals, SVOCs, phenolics, iron, sulfate, beryllium, cadmium, lead, manganese and elevated pH were found in the samples taken.

In order to define the health risk posed by the contamination, USX commissioned the ChemRisk Division of McLaren/Hart Environmental Engineering Corporation for this purpose. In March of 1995, ChemRisk issued a Preliminary Risk Assessment of the site. After being approved by the IEPA, ChemRisk produced a Final Risk Assessment, which defined remediation goals for each possible land use. The ecological risk assessment illustrates adverse effects to living organism in the natural ecology. In September 1996, WTI proposed a remediation report that reviewed the remediation that had taken place on the site. In response to this report the IEPA issued a No Further Remediation Letter to USX for the South Works Site in July of 1997. This letter denoted that USX had remediated the South Works Site to the level of residential and industrial use. However, the No Further Remediation Letter excluded several areas of the site including both the slips. No remediation has taken place in either the North or the South Vessel Slips.

As a response to community concern and involvement 3 Northwestern University students prepared an independent assessment of the site entitled "An Analysis of Natural Attenuation at the United States Steel South Works Site" in June 1997. This report evaluated the natural attenuation theory proposed by USX as a method for the natural degradation of contaminants in the vessel slips. This was done through analysis of contaminant loading, site characterization and remediation goals. The conclusion drawn was that the natural attenuation theory proposed by USX was not a viable solution to the degradation and migration of contamination present at the site.

2.2 Origin of Site Contaminants

There are a number of different sources for site contamination. They include the site fill (blast furnace slag), underground storage tanks (USTs), aboveground storage tanks (ASTs), 55-gallon drums, railroad ties, transformers and capacitors. The first on this list is blast furnace slag. Many chemicals are associated with blast furnace slag, some of which may be characterized as contaminants. The following table illustrates its typical composition.

Table 2-1

Chemical Composition of Blast Furnace Slag

Chemical Name	Chemical Formula	Percent Abundance
Silica	SiO_2	33 to 42
Alumina	Al_2O_3	10 to 16
Lime	CaO	36 to 45
Magnesia	MgO	3 to 12
Sulfur	S	1 to 3
Iron Oxide	FeO	0.3 to 2
Manganese oxide	MnO	0.2 to 1.5

Source: Josephson, 54

Out of the listed constituents, the oxides, which include Silica, Alumina, Lime and Magnesia, constitute approximately 95 percent of the total. The variability in relative abundance of the species is dependent upon the composition of the raw materials, grade of steel produced and operation of the blast furnace itself.

Storage tanks may pose another threat to contamination on the site. The Phase I identified 118 ASTs on the site filled with the following substances, sulfuric acid, boiler water treatment liquids and fire suppression materials. Out of this number 10 may have contained hazardous substances. Also distinguished were 2 USTs that contained petroleum products.

Fifty-five-gallon drums were located at 70 different locations throughout the site and there were 13 areas where railroad ties had been stockpiled. The contents of the 55-gallon drums are unknown. The preservation of railroad ties is achieved by the application of a number of different chemicals one of which is pentachlorophenol. Finally, 44 PCB transformers were found on the site, some of which may have been buried in demolition debris at 2 locations as part of the fill material. Also 493 PCB capacitors were accounted for. The existence of these materials may make PCBs, phenols, PCBs, PAHs, manganese and other metals available in the area (Draft Petition, 1999).

3.0 Data Analysis

Due to the insufficient information given from the vessel slip sediment samples it would be inaccurate to make recommendations. A method of estimation based on site information is a reasonable way to assess the extent of contamination in the sediments.

3.1 Contaminants of Concern

Certain steps were taken in order to identify the contaminants of concern in the vessel slip sediments. The data analyzed for this determination came from the Phase III Report.

Each type of sample, groundwater, soil and sediment was evaluated separately. Locations of the sampling stations are presented in Figure 3-1. The results of the laboratory analysis of the samples were listed in tables included in the report. A letter that had a given meaning accompanied each measurement. The letter "J" stood for approximate value, the letter "U" meant not detected at the reported concentration, the letters "UJ" represented not detected at approximate reported concentration and the letter "R" expressed that the value was rejected under National Functional Guidelines. If the measurement was accompanied by "J" this value was used in the evaluation. If it were accompanied by "U" or "UJ" then a value of half the number given (the detection limit) was used. It is a recognized practice to use a value of half the detection limit for additional evaluation. If the measurement had an "R" the value was discarded.

Each contaminant level value was compared to a set of standards. This standard was either the EPA Region III Risk Based Concentrations, for soil and sediment measurements, or Class I and II groundwater standards. Risk Based Concentrations, abbreviated as RBCs, originate from an absolute comparison of risk. The RBCs include values that have been calculated for over 600 contaminants in air, soil, drinking water and fish tissue, through the use of default EPA exposure parameters. The given RBC value is the contaminant level that corresponds to a hazard quotient of 0.1 or a lifetime cancer risk of 10^{-6} (Guide, 1989). Class I and II groundwater standards have been formulated by the EPA as well. The standards are based on the use of the water. Class I has been designated as potable for domestic uses such as drinking and bathing. Class II is designated as non-potable and use is more restricted. If one concentration was found to be above the standards it was added to the contaminants of concern list. This was done because, although a contaminant may not be at elevated levels throughout the site, it may be elevated at a location that will impact or has impacted the vessel slips.

3.1.1 Soil

In evaluation of soil boring samples, RBCs were used for comparison. Generally, the same RBC values were used as the Phase III, which were for the year 1994. However, for some compounds values from 1999 were used if there were large changes made since the 1994 version or if no values were available in the 1994 version. 1999 RBC values were used when evaluating arsenic, iron, chromium and nickel.

In addition, RBCs contain criteria for both industrial/commercial (industrial) and residential use. Residential criteria are lower than industrial because there is greater exposure in the former case. The chemical was listed as a contaminant of concern if it was above either the residential or industrial criteria.

In the course of the Phase III Report, a total of 48 soil borings were taken at 20 different locations on the site. The samples were analyzed for metals, VOCs, SVOCs, chloride, sulfate, phenol, ammonia, cyanide, sulfide and pH. Following are those contaminants designated as being of concern.

pH

The values of pH ranged from 7.58 to 12.93 the average being 9.96. In addition 12 samples had values greater than 11.0 and 35 greater than 9.0. The pH range for natural waters is 6.0 to 9.0. Although pH is not a criterion to be evaluated directly it controls chemical speciation, fate and impact as well as biological activity.

Beryllium

A total of 46 samples were taken and analyzed for beryllium. Out of these, 45 were above the residential RBC level and 38 exceeded the industrial.

Manganese

Thirty-six out of 46 samples analyzed were above the residential RBC value. Of the 36, 15 were also above the industrial value.

Benzo(a)pyrene

All the sample measurements or the detection limits were above residential RBC values. Measurable quantities of this PAH were detected in 12 out of 23 samples analyzed. Eleven of the 23 were above the industrial level.

Benzo(a)anthracene

The residential RBC was exceeded in four samples.

Benzo(b)fluoranthene

The residential RBC was exceeded in four samples.

Dibenz(a,h)anthracene

Measurements or the detection limits were above residential RBC values in 22 of 23 samples analyzed. In addition, 10 were measured or had detection limits above the industrial limit.

Indeno(1,2,3-cd)pyrene

The residential RBC value was exceeded in 2 samples.

Arsenic

Out of the 46 samples analyzed for this species, 42 were greater than the residential values and 21 were greater than the industrial.

Cadmium

One sample exceeded the residential value out of the 46 samples analyzed.

Vanadium

One sample exceeded the residential value out of the 46 samples analyzed.

3.1.2 Groundwater

A total of 20 groundwater samples were taken at various locations on the site. The samples were analyzed for metals, VOCs, SVOCs, chloride, sulfate, phenol, PCBs, cyanide, sulfide and pH. Contaminant levels measured were compared to Class I and Class II Groundwater Standards. The Phase III report stated that the values recorded for chloroform and methylene chloride were laboratory residuals. However, they gave no explanation on how this conclusion was made. Therefore, these two compounds are still considered in the assessment. The following contaminants of concern were identified. Values from 1999 were used for acetone, chloroform, methylene chloride, Di-n-butylphthalate and phenol.

pH

The pH of the samples ranged from 7.1 to 12.3 with 6 samples having pH values greater than 9.0.

Chloride

Two samples of those measured were above both Class I and Class II standards.

Phenolics

One sample of those measured was above both Class I and Class II standards.

Sulfate

Four samples of those analyzed exceeded Class I and Class II standards.

Cadmium

One sample analyzed was above Class I standards, but below Class II standards.

Iron

One sample measured was above Class I standards.

Manganese

Class I standards were exceeded in 6 samples.

Lead

One sample was above Class I standards.

Cyanide

The Class I groundwater standard was met in one sample.

3.1.3 Sediment

In evaluation of sediment samples, 1994 EPA Region III RBCs were used, the same criteria as for soil boring samples. However, for some compounds values from 1999 were used if there were either large changes made since the 1994 version or no values were available in the 1994 version. More recent RBCs were used in evaluating arsenic, iron, chromium and nickel.

Five sediment samples were taken in the vessel slips, three from the North Slip and two from the South Slip. All samples were taken along the centerline of the slips. The samples were analyzed for metals, VOCs, SVOCs, chloride, sulfate, phenols, PCBs, ammonia, cyanide, sulfide and pH. The following were characterized as contaminants of concern.

Beryllium

All samples were at or above the RBC residential and industrial standards.

Manganese

All samples taken were above residential RBC standards, however, none were above industrial standards.

3.1.4 Summary of Contaminants of Concern

The previous account of contaminants of concern is for the areas surrounding the sampling stations. In regards to the soil and groundwater samples this area encompasses the entire site. The objective of this document is to focus on assessment of the vessel slips only, therefore, not all sampling stations are representative of contribution to the slips. Taking into account the previously listed contaminants of concern and the locations of elevated contamination the following list of contaminants of concern has been devised. The COCs found in the vicinity of the vessel slips have been included and the remaining were discarded.

Table 3-1
Contaminants of Concern

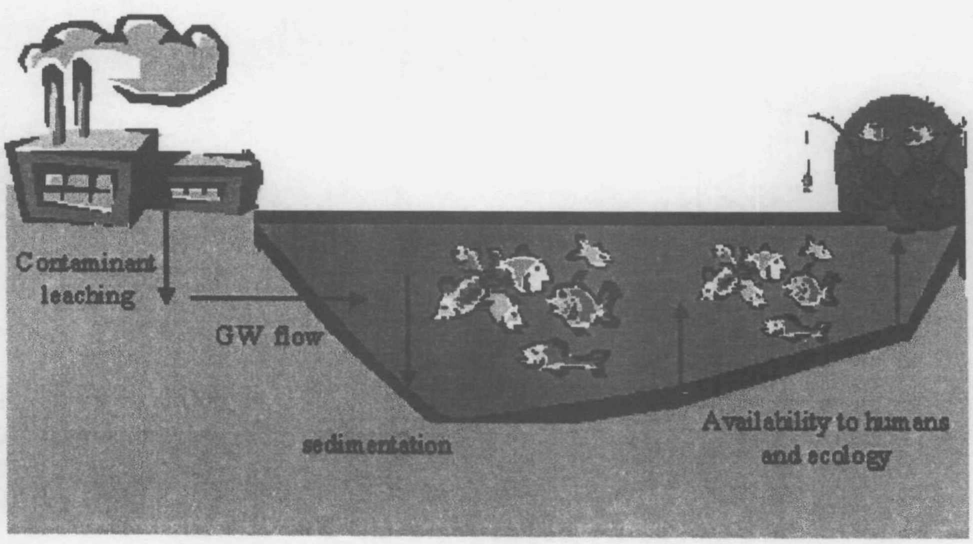
Metals	**PAHs**	**Other**
Arsenic	Benzo(a)pyrene	pH
Beryllium	Dibenz(a,h)anthracene	Chloroform
Cadmium	Indeno(1,2,3-cd)pyrene	Cyanide
Iron		Methylene Chloride
Lead		Phenol
Manganese		Phenolics
Vanadium		Sulfate

3.2 Framework Used for Chemical Transport and Fate

There is an insufficient amount of information on the condition of vessel slip sediments. The five sediment samples taken do not give a clear picture of what the slips contain other than the area immediately surrounding the sampling stations. Due to the small number of samples only a small area of the slips was covered. In order to assess the slips an estimate of contaminant loading from the site to the slips is necessary. The method of transport of the contaminants is groundwater. The mass concentration of contaminants per mass of sediment must be determined in order to compare this value with sediment criteria and determine if the sediments are harmful. Therefore, it is necessary to estimate the mass concentration of contaminants in the sediment. This value has been calculated through the use of mathematical equations and site information, which will be explained shortly.

The estimation of contaminants in groundwater is based on the conceptual model that follows.

Figure 3-2
Conceptual Model



Pollutants from plant processes have been deposited on the soil of the site and have migrated to the groundwater. Groundwater in the site is known to flow outward towards the vessel slips. Therefore, those contaminants dissolved in the groundwater will over time reach the water of the vessel slips. Once the contaminants reach the vessel slip surface water it is likely that they will attach particles. The particles settle out of the water and collect at the bottom of the slips forming sediments. The settling of particles is at a specific rate and the accumulation of particles in the sediments is derived from this value.

A total of four steps were taken in order to accomplish this estimation. In consecutive order they are determination of groundwater flow, contaminant concentrations in groundwater, contaminant loading and accumulation of contaminants in sediments.

The first step is to determine the groundwater flow on the site. Determination of groundwater flow is achieved through study of the hydrology of the site. After review of groundwater elevation maps one can ascertain the direction of groundwater flow for a particular area. Flow tubes can be devised that exhibit flow along a line. This tube is taken as representative of all GW in a select area. Once this is completed Darcy's Law can be implemented to calculate the volume flow of groundwater within the flow tubes. Darcy's law is a standard equation used for the calculation of groundwater flow. It is used in this circumstance with the assumption that all groundwater flow is constant and uniform. The mathematical expression is as follows:

Table 3-2
Darcy's Law Equation

$\frac{Q}{A} = K * \frac{(h1-h2)}{L}$	
Q=	volume of water per unit time
A=	cross-sectional area through which the water flows
K=	hydraulic conductivity
h1=	initial groundwater elevation
h2=	final groundwater elevation
L=	Length between initial and final elevations

See Appendix A1 for details.

Step 2, determination of contaminant concentrations in groundwater, means ascertaining the amount of contaminants dissolved in groundwater that can migrate to the vessel slips. The method of transport, in this case, is groundwater flow. The concentrations assigned to each flow tube originate from the groundwater measurement closest to it. If the groundwater measurement given is below the detection limits then a value of half this detection limit is used in the calculations.

The third step is contaminant loading. This can be achieved by using the following equation.

Table 3-3
Loading Equation

Q * [Contaminant]	
Q=	volume flow rate
[Contaminant]	Concentration of a particular contaminant

See Appendix A1 for details

This calculation is done for each contaminant in a given flow tube to learn the contaminant contribution from that route. Then the contributive flow tubes to each slip are added to give a final loading into the slip for each contaminant. There are two assumptions made in conjunction with this method of estimation. The first is that the contaminant concentration used in the calculations is assumed to be constant. Secondly, it is assumed that there is no loss to or addition of contaminants from the soil through which the groundwater flows.

The fourth and final step in the estimation is determination of the accumulation of contaminants into the sediments. This is performed by a series of calculations (refer to Appendix A4). A key element of these calculations is sedimentation rate. The sedimentation rate used is comprised of three separate rates. The first of these is a base rate set as the average rate for Lake Michigan. The second and third, which are subsequently added to the base rate, are the sedimentation rates for iron and manganese particulates. These rates are calculated using site information. Iron and manganese are both present in natural waters. The composition of the water, including pH, determines what species of the compounds will be dominant. The concentration of the species in the water is also dependent upon these same factors. Depending upon the amount of these metals present, a significant contribution can be made to the sedimentation rate (Stumm, 1996). Sedimentation rates will be discussed in greater detail in section 3.3.4.

Once the sedimentation rate is calculated the amount of particles added to the sediments is obtainable. All the chemical contaminants are assumed to attach to particles once they reach the vessel slip surface waters. Therefore, the amount of contaminants loaded is present in that volume of new sediment. The solution is given on a yearly basis, in units of mass of contaminant per mass of new sediment.

3.3 Chemical Transport and Fate

3.3.1 Groundwater Flow

First, we took into consideration the elevation of the groundwater table throughout the site. The groundwater elevation measurements used were taken on July 11, 1994. Based on those measurements a groundwater elevation map was constructed. In the Northwestern report flow lines were drawn perpendicular to the groundwater elevation lines. A total of 54 lines were drawn and designated as flow tubes. In addition to these, one extra flow tube was added during the course of this report, Figure 3-3. Length, width, height and head differences were defined for each flow tube by using the existing map and scaling the results to the correct dimensions. These values were used in subsequent calculations. The scope of this report only required the estimation of flows in those tubes leading directly to the vessel slips. Those select tubes and site information are listed in Table 3-4. Flow tubes leading to the North Slip were considered separately from those leading to the South Slip.

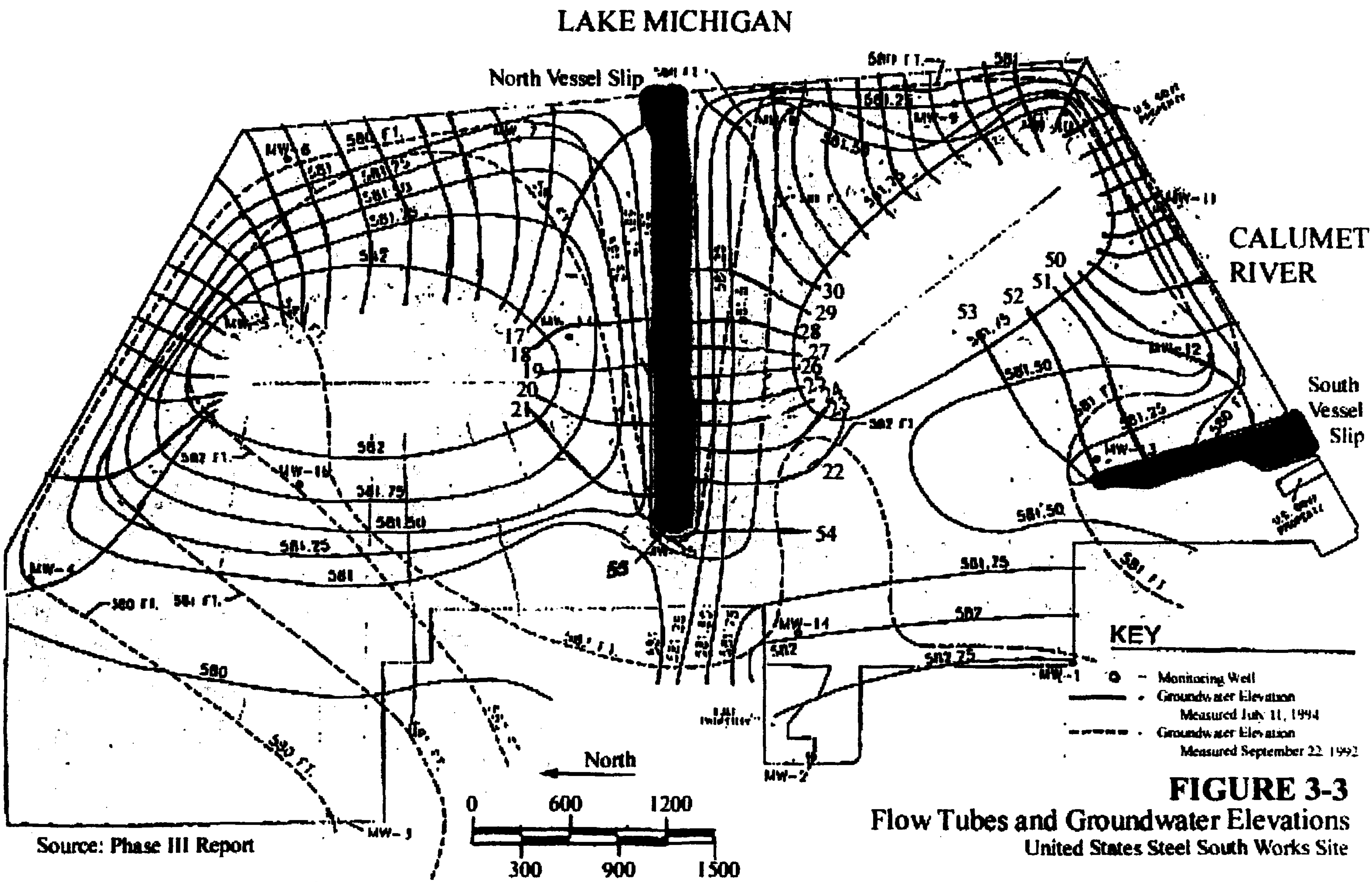


FIGURE 3-3
Flow Tubes and Groundwater Elevations
United States Steel South Works Site

Source: Phase III Report

Table 3-4
Selected Flow Tubes

Flow Tube	Length	Width	Height
North Slip			
17	1845	726	15
18	1480	1095	15
19	920	288	15
20	932	365	15
21	1115	438	15
22	1018	203	15
23	872	154	15
24	1038	134	15
25	1014	142	15
26	961	182	15
27	1054	146	15
28	1172	308	15
29	1500	1168	15
30	1735	454	15
54	811	284	15
55	60	300	15
South Slip			
50	1682	811	15
51	1784	701	15
52	1630	308	15
53	1780	81	15

Units are ft.

Hydraulic conductivity is a value that indicates groundwater flow properties through a medium. Due to the heterogeneous nature of the slag fill at the site, there was not a standard value for hydraulic conductivity. Thus, the hydraulic conductivity was calculated for each flow tube using the assumed flow velocity (Q/A) of 0.5ft/d (Bongiovanni et al. 1997). This value is an accepted assumption for the velocity in aquifers. The necessary data presented in the Table 3-4 was assessed in the Phase III (WTI, 1994). The data from each corresponding flow tube was put into an Excel spreadsheet and the hydraulic conductivity calculated using the data from all (selected and unselected) flow tubes. Minimum, average and maximum hydraulic conductivities were calculated. After receipt of these values it was possible to calculate the minimum, average and maximum volume flow through each selected flow tubes by the application of Darcy's Law. The hydraulic conductivities and volume flow rates are summarized in Tables 3-5 and 3-6.

Table 3-5
Summary of Hydraulic Conductivities

Minimum	460.0
Average	753.7
Maximum	1189.3

Table 3-6
Summary of Volume Flow Rates

Flow Tube	Minimum	Average	Maximum
North Slip			
17	2715.1	4448.9	7020.0
18	5105.1	8365.0	13199.2
19	2160.0	3539.3	5584.7
20	2702.3	4427.8	6986.7
21	2710.5	4441.3	7008.0
22	1031.9	1690.9	2668.1
23	913.9	1497.5	2363.0
24	668.1	1094.7	1727.3
25	724.7	1187.5	1873.7
26	980.1	1605.9	2534.0
27	716.8	1174.6	1853.4
28	1360.0	2228.4	3516.2
29	4029.6	6602.8	10418.6
30	1354.1	2218.9	3501.2
54	1812.2	2969.4	4685.5
55	8625.0	14132.6	22300.0
South Slip			
50	2495.2	4088.6	6451.4
51	2033.5	3331.9	5257.5
52	977.9	1602.3	2528.2
53	235.5	385.9	608.9

Units are cubic feet/day

3.3.2 Contaminant Concentrations

In order to find the loading of contaminants into the vessel slips it was necessary to find the concentrations of contaminants associated with the water in each selected flow tube. There are 16 tubes that flow towards the North Slip and 4 that flow towards the South Slip. For this analysis groundwater concentrations were used for each individual contaminant concentration. There are four monitoring wells in the vicinity of the selected flow tubes. Each flow tube was assumed to have a concentration of contaminants equal to that of the nearest monitoring well. This assumption may lead to lower vessel slip contamination than those actually present. In addition, the concentrations used are for samples taken in 1994. By this time the facility had been closed and most operations had ceased many years prior. Therefore, many of the contaminants would have had time to migrate to the vessel slips in the intervening years, yielding a lower concentration remaining in the groundwater in 1994. This may occur because the concentrations are at a specific moment in time and do not take into account hourly, daily or yearly fluctuations. There is more likely a greater concentration of contaminants already deposited in the deeper layers of sediment in the vessel slips.

3.3.3 Contaminant Loading

Loading was assessed using the equation expressed in the framework section of this report. Please refer to Table 3-3. Each contaminant concentration for a given flow tube was multiplied by the minimum, average and maximum volume flow rate to obtain a loading for that scenario. The answer was manipulated to express the solution in the units of kilograms per year (kg/yr). The solutions from each flow tube were added in order to achieve a final loading of each contaminant into the North Slip and the South Slip. This value is a measurement of the loading on a yearly basis, and specifically for the year 1994. A summary of the loadings is given in Table 3-7.

Table 3-7
Summary of Loadings

	Minimum		Average		Maximum	
Contaminant Name	North Slip	South Slip	North Slip	South Slip	North Slip	South Slip
Arsenic	0.65	0.03	1.06	0.05	1.68	0.08
Beryllium	0.54	0.27	0.89	0.44	1.40	0.70
Cadmium	0.93	0.13	1.52	0.21	2.39	0.33
Iron	2.85	2.75	4.66	4.51	7.36	7.12
Lead	0.17	0.03	0.29	0.04	0.45	0.07
Manganese	13.6	14.9	22.4	24.3	35.3	38.4
Vanadium	6.06	0.21	9.93	0.35	15.7	0.56
Chloroform	1.94	0.30	3.18	0.49	5.03	0.77
Cyanide	0.97	6.90	1.59	11.3	2.51	17.8
Methylene Chloride	1.94	0.30	3.18	0.49	5.03	0.77
Phenols	1.94	0.30	3.18	0.49	5.03	0.77
Phenolics	0.97	0.15	1.59	0.24	2.51	0.38
Sulfate	9.52E+04	3.89E+04	1.56E+05	6.37E+04	2.46E+05	1.01E+05

Units are in kg/yr

As can be seen from the table the loading of contaminants into the North Slip is generally larger than that of the South Slip. This is due in part to the greater number of flow tubes discharging into the North Slip. Please refer again to Figure 3-2. Due to the groundwater elevation information available it was possible to identify the flow tubes leading to the North Slip on its north, west and east sides. However, for the South Slip elevation information is only available on the east side of the slip. Thus, any flow tubes entering from the west side of the slip have not been accounted for. Therefore, the loading may be smaller than the actual and much smaller than that of the North Slip.

Loadings increase when going from minimum to average to maximum scenarios. Results show that iron, manganese, vanadium, chloroform, methylene chloride, phenols, and sulfate contribute the most to the contaminant loadings. All other constituents are present in smaller amounts. Whether the levels are elevated or not will be determined by comparison with background and standards concentrations. This procedure has been carried out and the results are listed in section 4.1.

3.3.4 Accumulation in Sediments

Thus, the contribution of each was evaluated. First, the volume of new sediment was found by multiplying the sedimentation rate by the volume of the slips. Next, the mass of particles was calculated by multiplying the particle density by the volume of new sediment. Finally, the accumulation was stated by dividing the loading by the mass of particles.

The first element is the calculation of sedimentation rate. As mentioned previously, the particulates contributed by iron and manganese are of great importance to the sedimentation rate. The base rate is that of Lake Michigan. The value chosen was the average rate equal to 1.5 cm/yr. The sedimentation rates for the second and third components, iron and manganese, were achieved in different manners. The addition of Fe^{2+} or Fe^{3+} reacts with water to from both soluble and insoluble compounds. There is continuous cycling between the two ion forms. We have assumed that the iron present in the water is in the form of iron hydroxide, $Fe(OH)_2(s)$. This compound takes into account most of the species formed and is therefore a reasonable assumption. Iron hydroxide precipitates in the structure of amorphous particles. These particles settle at the same rate as the other particles already present in the water. Using the solubility for this compound the mass required for saturation of the North Vessel Slip was calculated. Loading in excess of this value was added to the particulates in the system. The values were obtained by the use of several linked Excel spreadsheets included in Appendix A4. Manganese is also a common component of natural waters. The manganese in the groundwater was assumed to be in the form of the ion Mn^{2+}. This ion will precipitate in the form manganese oxide, $MnO_2(s)$. The same information was gained for the manganese system, except a computer modeling program was used. The program used was PHREEQC and it was provided by the United States Geological Survey (USGS). PHREEQC is a modeling program that uses thermodynamic principles to define the equilibrium concentration of chemical species. The input file is located in Appendix A4.

The results given have shown the contribution of iron and manganese from groundwater to the overall rate to be negligible. The sedimentation rate of the iron particles was on the order of 10^{-6} moles per liter and for manganese particles 10^{-13} moles per liter.

The final results are compiled in Table 3-8. The values given represent that accumulation on a yearly basis. Meaning that this is an estimate of the contaminant concentration in one year's deposition of sediment. The table shows that the greatest contributions of contaminants come from the compounds manganese and sulfate. Most concentrations increase modestly between minimum, average and maximum flows for the North and South Slips.

Table 3-8
Summary of Contaminant Accumulation in Sediments

	North Slip			South Slip		
	Minimum	Average	Maximum	Minimum	Average	Maximum
	(mg contaminant)/(kg sediment)					
Arsenic	0.73	1.19	1.87	0.06	0.11	0.17
Beryllium	0.61	0.99	1.57	0.54	0.88	1.39
Cadmium	1.03	1.70	2.67	0.25	0.41	0.65
Iron	3.18	5.21	8.22	5.46	8.95	14.13
Lead	0.20	0.32	0.51	0.05	0.09	0.14
Manganese	15.24	24.97	39.41	29.48	48.30	76.22
Vanadium	6.77	11.10	17.51	0.43	0.70	1.10
Chloroform	2.17	3.56	5.61	0.59	0.96	1.52
Cyanide	1.09	1.78	2.81	13.69	22.44	35.41
Methylene Chloride	2.17	3.56	5.61	0.59	0.96	1.52
Phenols	2.17	3.56	5.61	0.59	0.96	1.52
Phenolics	1.09	1.78	2.81	0.29	0.48	0.76
Sulfate	1.06E+05	1.74E+05	2.75E+05	7.72E+04	1.26E+05	2.00E+05

4.0 Evaluation of Contaminant Accumulation Estimation

4.1 Comparison to Standards

The final sediment concentrations estimated were compared to 4 different criteria; background levels from the Illinois Stream Sediments document and the TACO report, and both 1994 and 1999 RBC values. The background areas for this report are all in reference to industrial areas in the Chicago area. The results for the comparisons are presented in Tables 4-1 through 4-3. The letter "X" indicates elevated levels, and "N/A" indicates where information was not available.

Table 4-1
Estimation Comparison to Background Levels and Standards
Minimum Flow

	A		B		C		D	
	Value Exceeded							
Contaminant Name	N Slip	S Slip	N Slip	S Slip	N Slip	S Slip	N Slip	S Slip
Arsenic							X	
Beryllium	N/A	N/A	X		X	X		
Cadmium	X		X					
Iron					N/A	N/A		
Lead							N/A	N/A
Manganese								
Vanadium	N/A	N/A	N/A	N/A				
Chloroform	N/A	N/A	N/A	N/A	N/A	N/A		
Cyanide	N/A	N/A	X	X				
Methylene Chloride	N/A	N/A	N/A	N/A				
Phenol	N/A	N/A	N/A	N/A			N/A	N/A
Phenolics	N/A	N/A	N/A	N/A			N/A	N/A
Sulfate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

A Background levels from Illinois Stream Sediments document
B Background levels from TACO report
C 1994 RBC values
D 1999 RBC values

In the minimum flow scenario one of either background levels are exceeded in the North Slip for cadmium, beryllium and cyanide and only exceeded by cyanide in the South Slip. RBC values were exceeded in the North Slip for arsenic and beryllium and in the South Slip by arsenic only.

Table 4-2
Estimation Comparison to Background Levels and Standards
Average Flow

	A		B		C		D	
	Value Exceeded							
Contaminant Name	N Slip	S Slip	N Slip	S Slip	N Slip	S Slip	N Slip	S Slip
Arsenic							X	
Beryllium	N/A	N/A	X	X	X	X		
Cadmium	X		X					
Iron					N/A	N/A		
Lead							N/A	N/A
Manganese								
Vanadium	N/A	N/A	N/A	N/A				
Chloroform	N/A	N/A	N/A	N/A	N/A	N/A		
Cyanide	N/A	N/A	X	X				
Methylene Chloride	N/A	N/A	N/A	N/A				
Phenol	N/A	N/A	N/A	N/A			N/A	N/A
Phenolics	N/A	N/A	N/A	N/A			N/A	N/A
Sulfate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Comparison of the average flow rates with background levels indicate that cyanide and beryllium concentrations are elevated in the sediments of both the North and the South Slips. While cadmium is only elevated in the North Slip. Comparison of these same values to RBC values show heightened levels of arsenic in the North Slip and elevated levels of beryllium in both slips.

Table 4-3
Estimation Comparison to Background Levels and Standards
Maximum Flow

	A		B		C		D	
	Value Exceeded							
Contaminant Name	N Slip	S Slip	N Slip	S Slip	N Slip	S Slip	N Slip	S Slip
Arsenic							X	
Beryllium	N/A	N/A	X	X	X	X		
Cadmium	X	X	X	X				
Iron					N/A	N/A		
Lead							N/A	N/A
Manganese								
Vanadium	N/A	N/A	N/A	N/A				
Chloroform	N/A	N/A	N/A	N/A	N/A	N/A		
Cyanide	N/A	N/A	X	X				
Methylene Chloride	N/A	N/A	N/A	N/A				
Phenol	N/A	N/A	N/A	N/A			N/A	N/A
Phenolics	N/A	N/A	N/A	N/A			N/A	N/A
Sulfate	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

The maximum flow scenario has the greatest concentrations and therefore exceeds background levels and RBCs in more incidences than the minimum or average values. Beryllium, cadmium, and cyanide levels exceed background levels in both slips. In addition, arsenic and beryllium exceed RBC values in the North Slip. In the South Slip the level of beryllium is elevated.

4.2 Implications of Contamination

Comparison of the estimated concentrations indicates that arsenic, beryllium, cadmium and cyanide are at levels above that of the surrounding reference area. These levels may be a cause of adverse ecological and human health effects. Because the reference is an industrial area of the region the levels for background will be higher than for a pristine environment. Therefore, when the levels calculated are elevated in comparison to the reference then they are even higher than those of the natural environment. Thus, the greater contamination. It must be noted also, that no background levels were given for vanadium, chloroform, methylene chloride, phenol, phenolics or sulfate. Their absence may be due to the fact that they are not present at any level in the natural environment or the reference area in particular (with the exception of sulfate). If this is the case, than any level of vanadium, chloroform, methylene chloride, phenol or phenolics above background and may cause adverse effects. Some concentration of each of these contaminants was estimated. Although the effects of these contaminants cannot be evaluated, they cannot be dismissed. The levels present in the sediments may be elevated and the consequences are not defined.

The definition of RBC values denotes that elevation of these contaminants cause detrimental effects to humans. The previous comparison of the estimated sediment concentrations to RBCs indicate that the levels measured in the vessel slips cause adverse affects to humans and the natural ecology due to the elevated presence of arsenic and beryllium.

The values obtained through the estimation are conservative values, therefore, they are likely to be lower than the actual. This is due to a number of reasons. In reference to the South Vessel Slip only half the flow tubes in the vicinity are accounted for. The are no groundwater elevation lines shown on the west side of the South Slip in Figure 3-2. Therefore, the flow and contaminant concentrations that may be contributed from this portion are not accounted for. Thus, the loadings, and subsequently the accumulation, are decreased from the actual level present. Contaminant concentrations actually present may exceed background or RBC levels. Another explanation for conservative values originates from the contaminant concentrations used. As mentioned in section 3.3.2, the values used are that at a specific time in 1994. The concentrations at this point are likely to be lower than when the plant was in operation. The amount of contamination loading into the slips from previous years may have been higher. Thus, the concentrations in deeper levels of the sediment are likely to have greater levels of contaminants.

5.0 Conclusions/ Recommendations

5.1 Limitations

From the loading and accumulation formulas the concentration of metals and a few other contaminants could be estimated. The estimation could only be made for those contaminants found in the groundwater samples. Therefore, the estimation was fairly accurate for metals that partition greatly to the aqueous phase and were measured in the groundwater. Polyaromatic Hydrocarbons (PAHs) do not partition much to the aqueous phase and were not found in any measurable quantities in the groundwater samples taken. However, this does not indicate that there are no PAHs in the sediment of the vessel slips. PAHs are strongly attracted to particulate matter and tend to bind there. This is the reason why PAHs were found in the soil matrix of the site, but not in the groundwater. The areas around the vessel slips contained Benzo(a)pyrene, Bibenz (a,h)anthracene and Indeno(1,2,3-cd)pyrene at levels above EPA Risk Based Concentrations.

A pathway not assessed in this report was soil runoff. By this route, soil and its bound PAHs are flushed by stormwater over the site or through stormwater outfalls to the vessel slips. Once the soil has reached the surface water of the vessel slips, it would settle out and accumulate along the bottom of the slip. Both PAHs and TPHs were found at elevated levels in soil samples. The contribution from this pathway has not been assessed in the estimation. Therefore, it is probable that these contaminants have reached the vessel slip sediments, although their extent is unknown.

5.2 Conclusions

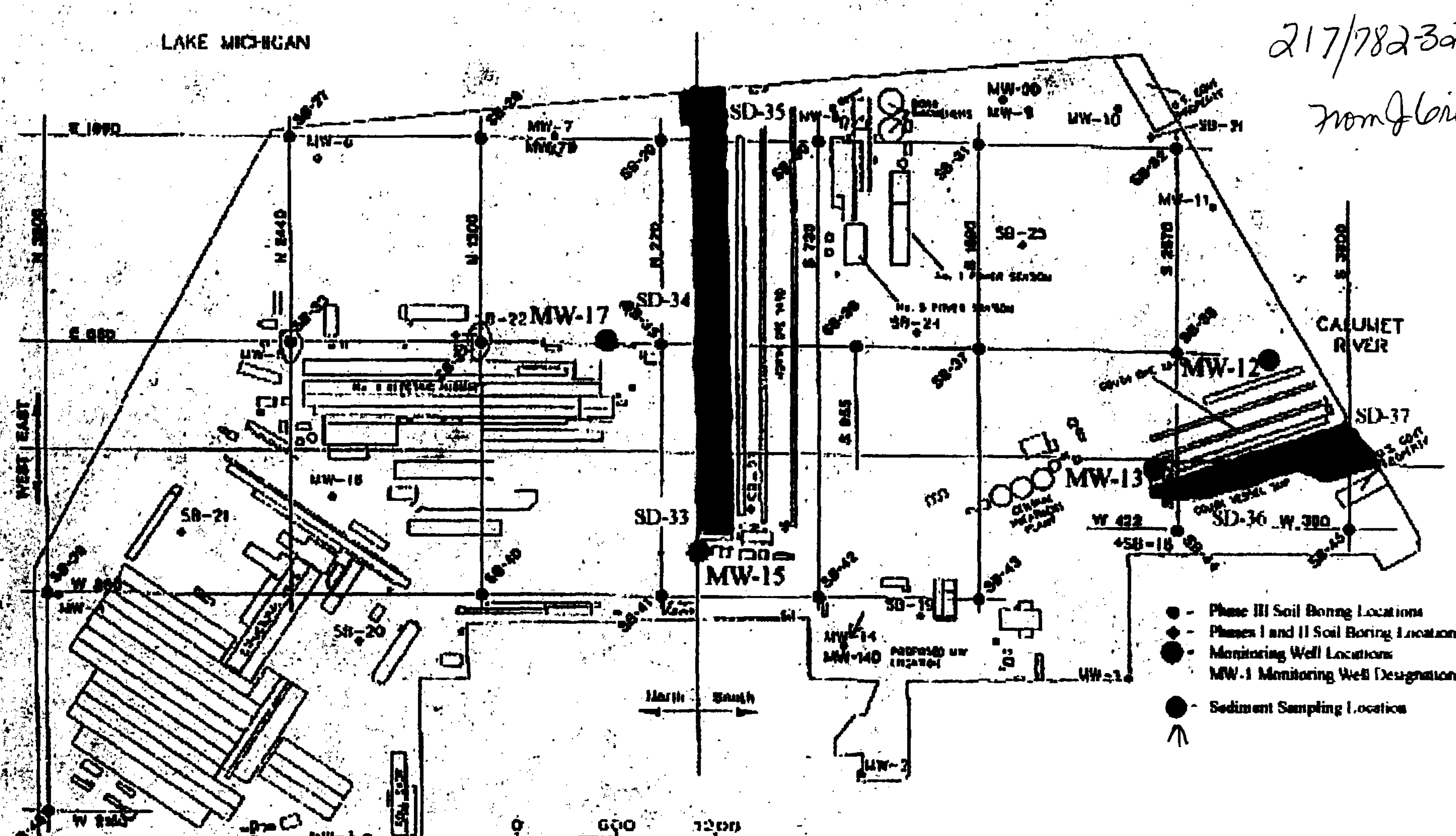
The first conclusion to be made is that based on the estimation there are contaminants in the vessel slips at elevated levels. The results of the contaminant estimation for USX shows that there may be heightened levels of arsenic, beryllium, cadmium and cyanide in the sediments. The presence of these contaminants is likely to cause adverse effects to both humans and ecology. The estimates are conservative values and the actual extent of contamination in the vessel slips may be greater. In addition, the limitations to this estimation indicate that there may be other contributions to the contamination not accounted for, including that of PAHs.

The second conclusion to be made is that exposure to the contaminants found in the vessel slips is likely to increase. The IEPA Pre-Notice Site Cleanup Program is designed to make the site suitable for redevelopment and resale. In fact a letter from the IEPA to USX in 1994 stated, "it is likely that a portion of the South Works site is to be developed as residential property, and it is therefore probable that some residents will fish these slips (Draft Petition, 1999)." Therefore, an increase in exposure to humans as compared to the present situation is likely to happen. This occurrence will cause the contaminants to have more deleterious effect with the increased exposure.

5.3 Recommendations

Taking into consideration all previous information the recommendation is for the creation and implementation of a new, more extensive sampling plan. This is necessary in order to confirm or deny the estimations of this report. Even the conservative estimation of this report yields contaminant concentrations in excessive levels. The sampling plan should provide an overall representation of the existence and location of contamination in the vessel slips. This sampling plan would entail a larger number of sampling stations than that performed in the Phase III. In addition, there needs to be sampling stations located along the banks of the vessel slips as well as along the centerline. Additional samples from the Calumet River and Lake Michigan would aid in characterizing the possible migration of contaminants out of the vessel slips. After the new samples are assessed it will be possible to determine the necessity for remediation of the vessel slips. The best means of remediation is dredging of the vessel slips. Removal of the source of contamination, the vessel slip sediments, will insure that the contaminants will not pose a problem presently or in the future. The dredging should be performed in conjunction with a monitoring program to insure the remediation is complete.

To M. WAGNER
217/782-3258
from J Griffin



WASTE TECHNOLOGY, INC.

FIGURE 3-1

Sediment, Soil and Monitoring Well Locatons

United States Steel South Works Site

Source: Phase III report, 1994

6.0 Framework Used for Risk Assessment

Under the Great Lakes Water Quality Agreement, the United States and Canada jointly agreed to address concerns about persistent toxic contaminants in the Great Lakes region. As a result, the USEPA, through the Great Lakes National Program Office (GLNPO), set up the Assessment and Remediation of Contaminated Sediments (ARCS) Program. Its primary goal is "to develop an integrated, comprehensive approach to assessing the extent and severity of sediment contamination" (USEPA, 1994a). A framework for risk assessment and modeling methods applicable to areas with sediment-derived contamination was established. This framework was followed in this report as a guideline for the ecological and human health risk assessments performed on the WSW vessel slips.

Risk assessment, as presented by the ARCS Program is "the process of producing qualitative or quantitative estimates of the potential risks associated with exposure to specific concentrations of contaminants under specific current or future exposure conditions at a site" (USEPA, 1993). Risk assessments are carried out for estimation of current health risks to both humans and wildlife exposed to contaminants found in the sediments. In this study, two separate risk assessment frameworks were used for human health receptors and ecological organisms.

Ecological risk assessments evaluate the likelihood of adverse effects associated with sediment-derived contaminants. For the purposes of this report, the ecological framework for risk assessment developed by the GLNPO office was followed. This includes a problem formulation phase, an ecological exposure and effects phase, and a final risk characterization phase (USEPA, 1993).

Problem Formulation

This first phase of the ecological risk assessment is covered in section 7.0 of this report. It defines the scope, approach and objectives of the assessment. The goal in this first step is to develop a site-conceptual model to illustrate how exposure to sediment-derived contaminants may affect organisms on site. This phase includes several steps:

1. Site Characterization

   This step includes a brief description of site history and previous investigations

2. Data Summary

   Data collected by the USFWS and IEPA is presented to build a model of the current state of the vessel slips.

3. Selection of contaminants of concern

   Contaminants of concern were selected by screening all sediment chemistry and surface water chemistry against background concentrations and sediment screening values. In addition, all chemicals detected in fish tissue were considered contaminants of concern.

4. Selection of species

   Species are selected as indicators of the site ecosystem. In this report, benthic organisms and fish were chosen as the site indicators. These will sometimes be grouped under the general term "aquatic organisms".

5. Exposure assessment

   A conceptual model of the site incorporates exposure routes as descriptions of how contaminants move through the physical environment of the vessel slips. These exposure pathways link potential adverse effects in organisms to contaminants found in the sediments and surface water of the vessel slips.

Ecological Exposure and Effects

In this phase, chemical measurements are used in contaminant transport and fate models to estimate the magnitude of exposure of organisms in the vessel slips to sediment-derived contaminants. Several models were used to represent the availability of contaminants to the organisms. These will be addressed further in sections 8.3 of this report. The last step in this phase is to determine the relationship between the levels of exposure and the types of effects observed in the organisms.

Risk Characterization

This is the final phase of the ecological risk assessment. It is a conclusion about the likelihood of adverse ecological effects associated with sediment-derived contaminants at the site.

A human health risk assessment was carried out to assess the magnitude, frequency, and duration of direct or indirect exposure of receptor populations to COCs from the WSW vessel slips. Exposure pathways were discussed first. The two exposure pathways considered were ingestion of contaminated fish and dermal contact with surface water during fishing activities. A brief description of data source is given. In the exposure assessment, quantification of the magnitude, frequency and duration of exposure is calculated. Finally, the risk characterization section combines the results to arrive at a conclusion.

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APPENDIX A1

Table
Hydraulic Conductivity
Assumed Flux = 0.5 ft d

Flow Tube	Measured from Map (cm)		Actual (ft)			h_1	h_2	K
	Area	Length	Length	Width	Height			
1	1.95	4.1	1662	791	15	582.00	581.00	831.0
2	0.7	4.1	1662	284	15	582.00	581.00	831.0
3	0.5	4.05	1642	203	15	582.00	581.00	821.0
4	0.79	4	1622	320	15	582.00	581.00	811.0
5	0.55	4	1622	223	15	582.00	581.00	811.0
6	0.62	3.95	1601	251	15	582.00	581.00	800.5
7	0.6	3.9	1581	243	15	582.00	581.00	790.5
8	0.81	3.7	1500	328	15	582.00	581.00	750.0
9	0.8	3.22	1305	324	15	582.00	581.00	652.5
10	0.68	2.71	1099	276	15	582.00	581.00	549.5
11	0.5	2.69	1091	203	15	582.00	581.00	545.5
12	0.43	2.55	1034	174	15	582.00	581.00	517.0
13	0.5	2.3	932	203	15	582.00	581.00	466.0
14	0.46	3.1	1257	186	15	582.00	581.00	628.5
15	1.69	2.65	1074	685	15	582.00	581.00	537.0
16	1.45	4.45	1804	588	15	582.00	581.00	902.0
17	1.79	4.55	1845	726	15	582.00	581.00	922.5
18	2.7	3.65	1480	1095	15	582.00	581.00	740.0
19	0.71	2.27	920	288	15	582.00	581.00	460.0
20	0.9	2.3	932	365	15	582.00	581.00	466.0
21	1.08	2.75	1115	438	15	582.00	581.00	557.5
22	0.5	2.51	1018	203	15	581.75	581.00	678.7
23	0.38	2.15	872	154	15	581.75	581.00	581.3
24	0.33	2.56	1038	134	15	581.75	581.00	692.0
25	0.35	2.5	1014	142	15	581.75	581.00	676.0
26	0.45	2.37	961	182	15	581.75	581.00	640.7
27	0.36	2.6	1054	146	15	581.75	581.00	702.7
28	0.76	2.89	1172	308	15	581.75	581.00	781.3
29	2.88	3.7	1500	1168	15	581.75	581.00	1000.0
30	1.12	4.28	1735	454	15	581.75	581.00	1156.7
31	0.51	4.08	1654	207	15	581.75	581.00	1102.7
32	0.32	3.9	1581	130	15	581.75	581.00	1054.0
33	0.41	3.55	1439	166	15	581.75	581.00	959.3
34	0.36	3.29	1334	146	15	581.75	581.00	889.3
35	0.39	3.7	1500	158	15	581.75	581.00	1000.0
36	0.4	258	1046	162	15	581.75	581.00	697.3
37	0.44	2.58	1046	178	15	581.75	581.00	697.3
38	0.41	2.3	932	166	15	581.75	581.00	621.3
39	0.42	2.05	831	170	15	581.75	581.00	554.0
40	1.1	1.92	778	446	15	581.75	581.00	518.7
41	0.89	2.2	892	361	15	581.75	581.00	594.7
42	0.4	1.8	730	162	15	581.75	581.00	486.7
43	0.34	1.89	766	138	15	581.75	581.00	510.7
44	0.3	2.25	912	122	15	581.75	581.00	608.0
45	0.35	2.5	1014	142	15	581.75	581.00	676.0
46	0.35	2.65	1074	142	15	581.75	581.00	716.0
47	0.35	2.79	1131	142	15	581.75	581.00	754.0
48	0.7	3.25	1318	284	15	581.75	581.00	878.7
49	0.81	3.55	1439	328	15	581.75	581.00	959.3

Table
Hydraulic Conductivity
Assumed Flux = 0.5 ft/d

Flow Tube	Measured from Map (cm)		Actual (ft)			h_1	h_2	K
	Area	Length	Length	Width	Height			
50	2	4.15	1682	811	15	581.75	581.00	1121.3
51	1.73	4.4	1784	701	15	581.75	581.00	1189.3
52	0.76	4.02	1630	308	15	581.75	581.00	1086.7
53	0.2	4.39	1780	81	15	581.75	581.00	1186.7
54	0.7	2	811	284	15	581.75	581.00	540.7

Minimum	460.0
Average	753.7
Maximum	1189.3

Table

Flow Volumes of Selected Flow Tubes-- Minimum

K= 460.0

Flow Tube	Length	Width	Height	h_1	h_2	Flow Volume
	ft	ft	ft	ft	ft	ft^3/d
North Slip						
17	1845	726	15	582.00	581.00	2715.1
18	1480	1095	15	582.00	581.00	5105.1
19	920	288	15	582.00	581.00	2160.0
20	932	365	15	582.00	581.00	2702.3
21	1115	438	15	582.00	581.00	2710.5
22	1018	203	15	581.75	581.00	1031.9
23	872	154	15	581.75	581.00	913.9
24	1038	134	15	581.75	581.00	668.1
25	1014	142	15	581.75	581.00	724.7
26	961	182	15	581.75	581.00	980.1
27	1054	146	15	581.75	581.00	716.8
28	1172	308	15	581.75	581.00	1360.0
29	1500	1168	15	581.75	581.00	4029.6
30	1735	454	15	581.75	581.00	1354.1
54	811	284	15	581.75	581.00	1812.2
55	60	300	15	581.25	581.00	8625.0
South Slip						
50	1682	811	15	581.75	581.00	2495.2
51	1784	701	15	581.75	581.00	2033.5
52	1630	308	15	581.75	581.00	977.9
53	1780	81	15	581.75	581.00	235.5

Table
Flow Volumes of Selected Flow Tubes-- Average

K= 753.7

Flow Tube	Length	Width	Height	h_1	h_2	Flow Volume
	ft	ft	ft	ft	ft	ft^3/d
North Slip						
17	1845	726	15	582.00	581.00	4448.9
18	1480	1095	15	582.00	581.00	8365.0
19	920	288	15	582.00	581.00	3539.3
20	932	365	15	582.00	581.00	4427.8
21	1115	438	15	582.00	581.00	4441.3
22	1018	203	15	581.75	581.00	1690.9
23	872	154	15	581.75	581.00	1497.5
24	1038	134	15	581.75	581.00	1094.7
25	1014	142	15	581.75	581.00	1187.5
26	961	182	15	581.75	581.00	1605.9
27	1054	146	15	581.75	581.00	1174.6
28	1172	308	15	581.75	581.00	2228.4
29	1500	1168	15	581.75	581.00	6602.8
30	1735	454	15	581.75	581.00	2218.9
54	811	284	15	581.75	581.00	2969.4
55	60	300	15	581.25	581.00	14132.6
South Slip						
50	1682	811	15	581.75	581.00	4088.6
51	1784	701	15	581.75	581.00	3331.9
52	1630	308	15	581.75	581.00	1602.3
53	1780	81	15	581.75	581.00	385.9

Table
Flow Volumes of Selected Flow Tubes-- Maximum

K= 1189.3

Flow Tube	Length	Width	Height	h_1	h_2	Flow Volume
	ft	ft	ft	ft	ft	ft^3/d
North Slip						
17	1845	726	15	582.00	581.00	7020.0
18	1480	1095	15	582.00	581.00	13199.2
19	920	288	15	582.00	581.00	5584.7
20	932	365	15	582.00	581.00	6986.7
21	1115	438	15	582.00	581.00	7008.0
22	1018	203	15	581.75	581.00	2668.1
23	872	154	15	581.75	581.00	2363.0
24	1038	134	15	581.75	581.00	1727.3
25	1014	142	15	581.75	581.00	1873.7
26	961	182	15	581.75	581.00	2534.0
27	1054	146	15	581.75	581.00	1853.4
28	1172	308	15	581.75	581.00	3516.2
29	1500	1168	15	581.75	581.00	10418.6
30	1735	454	15	581.75	581.00	3501.2
54	811	284	15	581.75	581.00	4685.5
55	60	300	15	581.25	581.00	22300.0
South Slip						
50	1682	811	15	581.75	581.00	6451.4
51	1784	701	15	581.75	581.00	5257.5
52	1630	308	15	581.75	581.00	2528.2
53	1780	81	15	581.75	581.00	608.9

APPENDIX A2

Concentrations of Contaminants

Flow Tube	Reference Well	Metals							Other						
		Arsenic	Beryllium	Cadmium	Iron	Lead	Manganese	Vanadium	pH	Chloroform	Cyanide	Methylene Chloride	Phenols	Phenolics	Sulfate
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		micro g/L	mg/L	micro g/L	micro g/L	mg/L	mg/L
Standard		-	-	0.05	5	0.0075	0.005	-	>11	100	0.1	400	0.2	5	5
North Slip															
17	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
18	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
19	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
20	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
21	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
22	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
23	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
24	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
25	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
26	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
27	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
28	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
29	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
30	MW-17	0.00210	0.00130	0.0013	0.0041	0.00045	0.0010	0.0189	11.3	5	0.0025	5	5	0.0025	170
54	MW-15	0.00055	0.00165	0.0052	0.0157	0.00045	0.1240	0.0070	8.02	5	0.0025	5	5	0.0025	440
55	MW-15	0.00055	0.00165	0.0052	0.0157	0.00045	0.1240	0.0070	8.02	5	0.0025	5	5	0.0025	440
South Slip															
50	MW-12	0.00055	0.00605	0.0013	0.0710	0.00045	0.0856	0.0033	7.88	5	0.2000	5	5	0.0025	1300
51	MW-13	0.00055	0.00340	0.0028	0.0275	0.00045	0.3770	0.0039	7.33	5	0.0520	5	5	0.0025	160
52	MW-13	0.00055	0.00340	0.0028	0.0275	0.00045	0.3770	0.0039	7.33	5	0.0520	5	5	0.0025	160
53	MW-13	0.00055	0.00340	0.0028	0.0275	0.00045	0.3770	0.0039	7.33	5	0.0520	5	5	0.0025	160

APPENDIX A3

Particle Density 1.3 g/cm^3
Sedimentation Rate 1.5 cm/yr
Area of North Slip 459,033,921 cm^2
Area of South Slip 258,488,773 cm^2
Time 10 yr

Flow Tube	Volume Flow		COCs												
			Metals							Other					
			Arsenic	Beryllium	Cadmium	Iron	Lead	Manganese	Vanadium	Chloroform	Cyanide	Methylene Chloride	Phenols	Phenolics	Sulfate
	ft^3/d	L/d	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	micro g/yr	mg/yr	micro g/yr	micro g/yr	mg/yr	mg/yr
	Minimum														
North Slip															
17	2715.1	76883.6	58931.3	36481.3	36481.3	115056.3	12628.1	26659.4	530381.3	140312506.6	70156.3	140312506.6	140312506.6	70156.3	4770625224.9
18	5105.1	144559.2	110804.6	68593.3	68593.3	216332.8	23743.8	50125.9	997241.5	263820498.6	131910.2	263820498.6	263820498.6	131910.2	8969896951.3
19	2160.0	61164.3	46882.4	29022.5	29022.5	91532.4	10046.2	21208.7	421941.8	111624825.6	55812.4	111624825.6	111624825.6	55812.4	3795244070.4
20	2702.3	76519.2	58651.9	36308.3	36308.3	114510.9	12568.3	26533.0	527867.5	139647474.2	69823.7	139647474.2	139647474.2	69823.7	4748014123.0
21	2710.5	76752.5	58830.8	36419.1	36419.1	114860.1	12606.6	26613.9	529477.1	140073305.1	70036.7	140073305.1	140073305.1	70036.7	4762492372.3
22	1031.9	29221.5	22398.3	13865.6	13865.6	43730.0	4799.6	10132.6	201584.6	53329272.1	26664.6	53329272.1	53329272.1	26664.6	1813195252.6
23	913.9	25879.7	19836.8	12279.9	12279.9	38728.9	4250.7	8973.8	178530.9	47230400.9	23615.2	47230400.9	47230400.9	23615.2	1605833631.7
24	668.1	18917.4	14500.2	8976.3	8976.3	28309.9	3107.2	6559.6	130501.8	34524296.8	17262.1	34524296.8	34524296.8	17262.1	1173826090.3
25	724.7	20521.3	15729.6	9737.4	9737.4	30710.1	3370.6	7115.8	141566.2	37451376.6	18725.7	37451376.6	37451376.6	18725.7	1273346804.5
26	980.1	27752.5	21272.3	13168.6	13168.6	41531.7	4558.4	9623.2	191450.8	50648361.1	25324.2	50648361.1	50648361.1	25324.2	1722044276.7
27	716.8	20298.6	15558.9	9631.7	9631.7	30376.9	3334.1	7038.6	140030.1	37045003.6	18522.5	37045003.6	37045003.6	18522.5	1259530122.[illegible]
28	1360.0	38510.4	29518.2	18273.2	18273.2	57630.8	6325.3	13353.5	265663.8	70281415.7	35140.7	70281415.7	70281415.7	35140.7	2389568134.5
29	4029.6	114105.4	87461.8	54143.0	54143.0	170758.7	18741.8	39566.0	787155.9	208242313.5	104121.2	208242313.5	208242313.5	104121.2	7080238660.[illegible]
30	1354.1	38345.2	29391.6	18194.8	18194.8	57383.6	6298.2	13296.2	264524.3	69979972.9	34990.0	69979972.9	69979972.9	34990.0	2379319079.[illegible]
54	1812.2	51315.9	10301.7	30905.0	97397.6	294065.8	8428.6	2322558.0	131112.1	93651531.1	46825.8	93651531.1	93651531.1	46825.8	8241334740.[illegible]
55	8625.0	244232.4	49029.7	147089.0	463553.1	1399573.8	40115.2	11053958.4	624013.8	445724130.0	222862.1	445724130.0	445724130.0	222862.1	39223723440.0
TOTAL		**mg/yr**	**649,100**	**543,089**	**926,046**	**2,845,093**	**174,923**	**13,643,316**	**6,063,044**	**1,943,587**	**971,793**	**1,943,587**	**1,943,587**	**971,793**	**95,208,232,974**
South Slip															
50	2495.2	70656.1	14184.2	156026.2	33526.3	1831051.7	11605.3	2207577.8	83815.7	128947301.8	5157892.1	128947301.8	128947301.8	64473.7	33526298472.7
51	2033.5	57580.8	11559.3	71457.8	58847.6	577967.3	9457.6	7923406.0	81966.3	105084960.2	1092883.6	105084960.2	105084960.2	52542.5	3362718727.5
52	977.9	27689.7	5558.7	34362.9	28298.8	277935.0	4548.0	3810235.8	39416.2	50533631.4	525549.8	50533631.4	50533631.4	25266.8	1617076205.6
53	235.5	6668.4	1338.7	8275.4	6815.1	66933.7	1095.3	917600.7	9492.4	12169771.2	126565.6	12169771.2	12169771.2	6084.9	389432678.1
TOTAL		**mg/yr**	**32,641**	**270,122**	**127,488**	**2,753,888**	**26,706**	**14,858,820**	**214,691**	**296,736**	**6,902,891**	**296,736**	**296,736**	**148,368**	**38,895,526,084**

Particle Density 1.3 g/cm^3
Sedimentation Rate 1.5 cm/yr
Area of North Slip 459,033,921 cm^2
Area of South Slip 258,488,773 cm^2
Time 10 yr

Flow Tube	Volume Flow		COCs												
			Metals							Other					
			Arsenic	Beryllium	Cadmium	Iron	Lead	Manganese	Vanadium	Chloroform	Cyanide	Methylene Chloride	Phenols	Phenolics	Sulfate
	ft^3/d	L/d	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	micro g/yr	mg/yr	micro g/yr	micro g/yr	mg/yr	mg/yr
	Average														
North Slip															
17	4448.9	125978.9	96562.8	59777.0	59777.0	188527.4	20692.0	43683.2	869065.2	229911418.8	114955.7	229911418.8	229911418.8	114955.7	7816988240.9
18	8365.0	236869.9	181560.8	112394.8	112394.8	354475.8	38905.9	82134.6	1634046.8	432287517.4	216143.8	432287517.4	432287517.4	216143.8	14697775592.3
19	3539.3	100221.8	76820.0	47555.2	47555.2	149981.9	16461.4	34751.9	691379.9	182904736.4	91452.4	182904736.4	182904736.4	91452.4	6218761036.8
20	4427.8	125381.8	96105.1	59493.6	59493.6	187633.8	20594.0	43476.1	864946.1	228821718.8	114410.9	228821718.8	228821718.8	114410.9	7779938439.4
21	4441.3	125764.1	96398.2	59675.1	59675.1	188206.0	20656.8	43608.7	867583.6	229519471.1	114759.7	229519471.1	229519471.1	114759.7	7803662018.5
22	1690.9	47881.4	36701.1	22719.7	22719.7	71654.5	7864.5	16602.9	330309.9	87383576.3	43691.8	87383576.3	87383576.3	43691.8	2971041593.1
23	1497.5	42405.6	32503.9	20121.4	20121.4	63459.9	6965.1	14704.1	292534.8	77390168.2	38695.1	77390168.2	77390168.2	38695.1	2631265719.6
24	1094.7	30997.5	23759.6	14708.3	14708.3	46387.7	5091.3	10748.4	213836.0	56570367.4	28285.2	56570367.4	56570367.4	28285.2	1923392493.1
25	1187.5	33625.5	25774.0	15955.3	15955.3	50320.6	5523.0	11659.7	231965.7	61366583.4	30683.3	61366583.4	61366583.4	30683.3	2086463834.0
26	1605.9	45474.4	34856.1	21577.6	21577.6	68052.4	7469.2	15768.2	313704.9	82990724.3	41495.4	82990724.3	82990724.3	41495.4	2821684627.6
27	1174.6	33260.7	25494.3	15782.2	15782.2	49774.6	5463.1	11533.1	229448.7	60700714.0	30350.4	60700714.0	60700714.0	30350.4	2063824276.7
28	2228.4	63101.8	48367.5	29941.8	29941.8	94431.9	10364.5	21880.6	435307.8	115160796.4	57580.4	115160796.4	115160796.4	57580.4	3915467077.7
29	6602.8	186969.3	143312.0	88716.9	88716.9	279799.5	30709.7	64831.6	1289807.6	341218947.1	170609.5	341218947.1	341218947.1	170609.5	11601444200.8
30	2218.9	62831.2	48160.1	29813.4	29813.4	94026.8	10320.0	21786.7	433440.7	114666862.2	57333.4	114666862.2	114666862.2	57333.4	3898673315.7
54	2969.4	84084.5	16880.0	50639.9	159592.5	481846.5	13810.9	3805666.4	214836.0	153454292.3	76727.1	153454292.3	153454292.3	76727.1	13503977721.0
55	14132.6	400191.1	80338.4	241015.1	759562.7	2293295.1	65731.4	18112649.6	1022488.3	730348773.7	365174.4	730348773.7	730348773.7	365174.4	64270692087.6
TOTAL		**mg/yr**	**1,063,594**	**889,887**	**1,517,388**	**4,661,874**	**286,623**	**22,355,486**	**9,934,702**	**3,184,697**	**1,592,348**	**3,184,697**	**3,184,697**	**1,592,348**	**156,005,052,275**
South Slip															
50	4088.6	115774.7	23241.8	255659.4	54935.1	3000300.6	19016.0	3617263.8	137337.7	211288771.3	8451550.9	211288771.3	211288771.3	105644.4	54935080532.8
51	3331.9	94350.0	18940.8	117088.3	96425.7	947038.0	15497.0	12983030.2	134307.2	172188729.9	1790762.8	172188729.9	172188729.9	86094.4	55100393588.3
52	1602.3	45371.4	9108.3	56305.9	46369.5	455415.0	7452.2	6243326.0	64586.1	82802732.1	861148.4	82802732.1	82802732.1	41401.4	26496874288.4
53	385.9	10926.6	2193.5	13559.9	11167.0	109675.4	1794.7	1503550.1	15554.0	19940983.4	207386.2	19940983.4	19940983.4	9970.5	638111467.9
TOTAL		**mg/yr**	**53,484**	**442,613**	**208,897**	**4,512,429**	**43,760**	**24,347,170**	**351,785**	**486,221**	**11,310,848**	**486,221**	**486,221**	**243,111**	**63,732,918,787**

article Density 1.3 g/cm^3
edimentation Rate 1.5 cm/yr
.rea of North Slip 459,033,921 cm^2
rea of South Slip 258,488,773 cm^2
ime 10 yr

low Tube	Volume Flow		COCs												
			Metals							Other					
			Arsenic	Beryllium	Cadmium	Iron	Lead	Manganese	Vanadium	Chloroform	Cyanide	Methylene Chloride	Phenols	Phenolics	Sulfate
	ft^3/d	L/d	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	mg/yr	micro g/yr	mg/yr	micro g/yr	micro g/yr	mg/yr	mg/yr
	Maximum														
Vorth Slip															
17	7020.0	198783.0	152367.2	94322.5	94322.5	297478.8	32650.1	68928.0	1371304.6	362779002.6	181389.5	362779002.6	362779002.6	181389.5	12334486088.7
18	13199.2	373758.8	286486.1	177348.6	177348.6	559330.0	61389.9	129600.9	2578375.1	682109810.8	341054.9	682109810.8	682109810.8	341054.9	23191733566.8
19	5584.7	158140.7	121214.9	75037.8	75037.8	236657.6	25974.6	54835.3	1090933.7	288606795.5	144303.4	288606795.5	288606795.5	144303.4	9812631045.8
20	6986.7	197840.9	151645.0	93875.5	93875.5	296068.8	32495.4	68601.3	1364805.1	361059556.5	180529.8	361059556.5	361059556.5	180529.8	12276024920.9
21	7008.0	198444.1	152107.4	94161.7	94161.7	296971.6	32594.4	68810.5	1368966.9	362160545.3	181080.3	362160545.3	362160545.3	181080.3	12313458539.5
22	2668.1	75552.4	57911.0	35849.6	35849.6	113064.2	12409.5	26197.8	521198.6	137883219.6	68941.6	137883219.6	137883219.6	68941.6	4688029464.7
23	2363.0	66912.1	51288.1	31749.8	31749.8	100133.9	10990.3	23201.8	461593.0	122114543.9	61057.3	122114543.9	122114543.9	61057.3	4151894491.1
24	1727.3	48911.1	37490.4	23208.3	23208.3	73195.5	8033.7	16959.9	337413.5	89262819.5	44631.4	89262819.5	89262819.5	44631.4	3034935862.5
25	1873.7	53058.0	40668.9	25176.0	25176.0	79401.3	8714.8	18397.9	366020.4	96830805.6	48415.4	96830805.6	96830805.6	48415.4	3292247390.2
26	2534.0	71754.4	54999.7	34047.4	34047.4	107380.4	11785.7	24880.8	494997.4	130951704.6	65475.9	130951704.6	130951704.6	65475.9	4452357955.9
27	1853.4	52482.3	40227.7	24902.8	24902.8	78539.7	8620.2	18198.2	362048.9	95780125.2	47890.1	95780125.2	95780125.2	47890.1	3256524258.0
28	3516.2	99568.8	76319.5	47245.4	47245.4	149004.7	16354.2	34525.5	686875.6	181713109.6	90856.6	181713109.6	181713109.6	90856.6	6178245727.4
29	10418.6	295020.3	226133.0	139987.1	139987.1	441497.8	48457.1	102298.3	2035197.4	538412010.6	269206.0	538412010.6	538412010.6	269206.0	18306008302.1
30	3501.2	99141.8	75992.2	47042.8	47042.8	148365.7	16284.0	34377.4	683929.5	180933727.1	90466.9	180933727.1	180933727.1	90466.9	6151746720.7
54	4685.5	132677.7	26635.0	79905.1	251822.2	760309.3	21792.3	6004990.5	338991.4	242136712.4	121068.4	242136712.4	242136712.4	121068.4	21308030690.2
55	22300.0	631464.6	126766.5	380299.6	1198519.9	3618608.1	103718.1	28580089.6	1613392.2	1152422968.0	576211.5	1152422968.0	1152422968.0	576211.5	101413221184.0
TOTAL		**mg/yr**	**1,678,253**	**1,404,160**	**2,394,297**	**7,356,008**	**452,264**	**35,274,894**	**15,676,043**	**5,025,157**	**2,512,579**	**5,025,157**	**5,025,157**	**2,512,579**	246,161,576,269

South Slip															
50	6451.4	182681.7	36673.4	403407.0	86682.5	4734197.4	30005.5	5707708.4	216706.2	333394183.3	13335767.3	333394183.3	333394183.3	166697.1	86682487645.4
51	5257.5	148875.6	29886.8	184754.6	152150.8	1494338.6	24452.8	20486023.6	211924.4	271697926.2	2825658.4	271697926.2	271697926.2	135849.0	8694333638.4
52	2528.2	71591.8	14372.1	88845.4	73166.8	718602.9	11759.0	9851392.3	101911.0	130655070.2	1358812.7	130655070.2	130655070.2	65327.5	4180962247.6
53	608.9	17241.1	3461.2	21396.2	17620.4	173057.7	2831.9	2372463.4	24542.7	31465031.6	327236.3	31465031.6	31465031.6	15732.5	1006881011.1
TOTAL		**mg/yr**	**84,393**	**698,403**	**329,621**	**7,120,197**	**69,049**	**38,417,588**	**555,084**	**767,212**	**17,847,475**	**767,212**	**767,212**	**383,606**	100,564,664,542

APPENDIX A4

PART 1: Loading

	North Slip			South Slip		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Arsenic	649,100	1,063,594	1,678,253	32,641	53,484	84,393
Beryllium	543,089	889,887	1,404,160	270,122	442,613	698,403
Cadmium	926,046	1,517,388	2,394,297	127,488	208,897	329,621
Iron	2,845,093	4,661,874	7,356,008	2,753,888	4,512,429	7,120,197
Lead	174,923	286,623	452,264	26,706	43,760	69,049
Manganese	13,643,316	22,355,486	35,274,894	14,858,820	24,347,170	38,417,588
Vanadium	6,063,044	9,934,702	15,676,043	214,691	351,785	555,084
Chloroform	1,943,587	3,184,697	5,025,157	296,736	486,221	767,212
Cyanide	971,793	1,592,348	2,512,579	6,902,891	11,310,848	17,847,475
Methylene Chloride	1,943,587	3,184,697	5,025,157	296,736	486,221	767,212
Phenols	1,943,587	3,184,697	5,025,157	296,736	486,221	767,212
Phenolics	971,793	1,592,348	2,512,579	148,368	243,111	383,606
Sulfate	95,208,232,974	156,005,052,275	246,161,576,269	38,895,526,084	63,732,918,787	100,564,664,542

PART 2: Volume of New Sediment

Sedimentation Rate 1.5 cm/yr
Area of North Slip 459,033,921 cm^2

	North Slip	Units	South Slip	Units
Sedimentation Rate	1.5	cm/yr	1.5	cm/yr
Area	459,033,921	cm^2	258,488,773	cm^2
Volume	688,550,882	cm^3	387,733,160	cm^3
	688.55	m^3	387.73	m^3

PART 3: Mass of Particles

	Units	North Slip	South Slip
Particle Density	g/cm^3	1.3	1.3
Volume of New Sediment	cm^3	688,550,882	387,733,160
Mass of Particles	g	895,116,146	504,053,107
	kg	895,116.1	504,053.1

PART 4: Accumulation in Sediments

	North Slip			South Slip		
	Minimum	Average	Maximum	Minimum	Average	Maximum
	(mg contaminant)/(kg sediment)					
Arsenic	0.725	1.188	1.875	0.065	0.106	0.167
Beryllium	0.607	0.994	1.569	0.536	0.878	1.386
Cadmium	1.035	1.695	2.675	0.253	0.414	0.654
Iron	3.178	5.208	8.218	5.463	8.952	14.126
Lead	0.195	0.320	0.505	0.053	0.087	0.137
Manganese	15.242	24.975	39.408	29.479	48.303	76.217
Vanadium	6.773	11.099	17.513	0.426	0.698	1.101
Chloroform	2.171	3.558	5.614	0.589	0.965	1.522
Cyanide	1.086	1.779	2.807	13.695	22.440	35.408
Methylene Chloride	2.171	3.558	5.614	0.589	0.965	1.522
Phenols	2.171	3.558	5.614	0.589	0.965	1.522
Phenolics	1.086	1.779	2.807	0.294	0.482	0.761
Sulfate	106,364.11	174,284.70	275,005.18	77,165.53	126,440.88	199,512.04

APPENDIX B

Hydraulic Conductivity Sample Calculation

Rearranging Darcy's Law equation:

$$K = \frac{QL}{A(h1-h2)}$$

Q=	volume of water per unit time
A=	cross-sectional area through which the water flows
K=	hydraulic conductivity
h1=	initial groundwater elevation
h2=	final groundwater elevation
L=	Length between initial and final elevations

In the case of flow tube 20:

$Q/A = 0.5$ ft/d
$L = 932$ ft
$h1 = 582.0$ ft
$h2 = 581.0$ ft

Therefore:

$$K = \frac{(0.5 \text{ ft/d})(932 \text{ ft})}{(582.0-581.0)\text{ft}}$$

The solution is:

$K = 466$ ft/d

APPENDIX C

Sources: I = IRIS H = HEAST A = HEAST Alternate W = Withdrawn from IRIS or HEAST
E = EPA-NCEA provisional value O = other

Basis: C = Carcinogenic effects N = Noncarcinogenic effects I = RBC at HI of 0.1 < RBC-c

							Risk-based concentrations					Region III SSLs Soil, for groundwater migration	
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	[illegible] mg/kg	DAF 1 mg/kg	DAF 20 mg/kg
ACETALDEHYDE	75070			2.57E-003 I	7.7E-003 I	y	1.6E+000 C	8.1E-001 C				3.8E-004	7.7E-003 C
ACETOCHLOR	34256821	2E-002 I					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N		
ACETONE	67641	1.00E-001 I				y	6.1E+002 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	1.2E-001	[illegible] N
ACETONITRILE	75058			1.7E-002 I		y	1.2E+002 N	6.2E+001 N				2.9E-002	[illegible] N
ACETOPHENONE	98862	1.00E-001 I		5.70E-006 W		y	4.2E-002 N	2.1E-002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	1.1E-005	[illegible] N
ACROLEIN	107028	2.00E-002 H		5.70E-006 I		y	4.2E-002 N	2.1E-002 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	1.0E-005	[illegible] N
ACRYLAMIDE	79061	2.00E-004 I	4.50E+000 I		4.50E+000 I		1.5E-002 C	1.4E-003 C	7.0E-004 C	1.3E+000 C	1.4E-001 C	3.7E-006	[illegible] C
ACRYLONITRILE	107131	1.00E-003 H	5.40E-001 I	5.70E-004 I	2.40E-001 I	y	3.7E-002 C	2.6E-002 C	5.8E-003 C	1.1E+001 C	1.2E+000 C	7.4E-006	[illegible] C
ALACHLOR	15972608	1.00E-002 I	8.00E-002 H				8.4E-001 C	7.8E-002 C	3.9E-002 C	7.2E+001 C	8.0E+000 C	3.5E-004	[illegible] C
ALAR	1596845	1.50E-001 I					5.5E+003 N	5.5E+002 N	2.0E+002 N	3.1E+005 N	1.2E+004 N		
ALDICARB	116063	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N	1.0E-002	[illegible] N
ALDICARB SULFONE	1646884	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N	7.5E-003	[illegible] N
ALDRIN	309002	3.00E-005 I	1.70E+001 I		1.70E+001 I		3.9E-003 C	3.7E-004 C	1.9E-004 C	3.4E-001 C	3.8E-002 C	3.8E-004	[illegible] C
ALUMINUM	7429905	1.00E+000 E		1.00E-003 E			3.7E+004 N	3.7E+000 N	1.4E+003 N	2.0E+006 N	7.8E+004 N		
AMINODINITROTOLUENES		6.00E-005 E					2.2E+000 N	2.2E-001 N	8.1E-002 N	1.2E+002 N	4.7E+000 N		
4-AMINOPYRIDINE	504245	2.00E-005 H					7.3E-001 N	7.3E-002 N	2.7E-002 N	4.1E+001 N	1.6E+000 N		
AMMONIA	7664417			2.86E-002 I		y	2.1E+002 N	1.0E+002 N					
ANILINE	62533	7.00E-003 E	5.70E-003 I	2.90E-004 I			1.2E+001 C	1.1E+000 N	5.5E-001 C	1.0E+003 C	1.1E+002 C I	6.8E-003	[illegible] C
ANTIMONY	7440360	4.00E-004 I					1.5E+001 N	1.5E+000 N	5.4E-001 N	8.2E+002 N	3.1E+001 N	6.6E-001	[illegible] N
ANTIMONY PENTOXIDE	1314609	5.00E-004 H					1.8E+001 N	1.8E+000 N	6.8E-001 N	1.0E+003 N	3.9E+001 N		
ANTIMONY TETROXIDE	1332816	4.00E-004 H					1.5E+001 N	1.5E+000 N	5.4E-001 N	8.2E+002 N	3.1E+001 N		
ANTIMONY TRIOXIDE	1309644	4.00E-004 H		5.70E-005 I			1.5E+001 N	2.1E-001 N	5.4E-001 N	8.2E+002 N	3.1E+001 N		
ARSENIC	7440382	3.00E-004 I	1.50E+000 I		1.51E+001 I		4.5E-002 C	4.1E-004 C	2.1E-003 C	3.8E+000 C	4.3E-001 C	1.3E-003	[illegible] C
ARSINE	7784421			1.40E-005 I		y	1.0E-001 N	5.1E-002 N					
ASSURE	76578148	9.00E-003 I					3.3E+002 N	3.3E+001 N	1.2E+001 N	1.8E+004 N	7.0E+002 N		
ATRAZINE	1912249	3.50E-002 I	2.20E-001 H				3.0E-001 C	2.8E-002 C	1.4E-002 C	2.6E+001 C	2.9E+000 C	4.4E-004	[illegible] C
AZOBENZENE	103333		1.10E-001 I		1.10E-001 I		6.1E-001 C	5.7E-002 C	2.9E-002 C	5.2E+001 C	5.8E+000 C	1.8E-003	[illegible] C
BARIUM	7440393	7.00E-002 I		1.40E-004 A			2.6E+003 N	5.1E-001 N	9.5E+001 N	1.4E+005 N	5.5E+003 N	1.1E+002	[illegible] N
BAYGON	114261	4.00E-003 I					1.5E+002 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N		
BAYTHROID	68359375	2.50E-002 I					9.1E+002 N	9.1E+001 N	3.4E+001 N	5.1E+004 N	2.0E+003 N		
BENTAZON	25057890	3.00E-002 I					1.1E+003 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N		
BENZALDEHYDE	100527	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
BENZENE	71432	3.00E-003 E	2.90E-002 I	1.70E-003 E	2.90E-002 I	y	3.6E-001 C	2.2E-001 C	1.1E-001 C	2.0E+002 C	2.2E+001 C	1.0E-004	[illegible] C
BENZENETHIOL	108985	1.00E-005 H				y	6.1E-002 N	3.7E-002 N	1.4E-002 N	2.0E+001 N	7.8E-001 N		
BENZIDINE	92875	3.00E-003 I	2.30E+002 I		2.30E+002 I		2.9E-004 C	2.7E-005 C	1.4E-005 C	2.5E-002 C	2.8E-003 C		
BENZOIC ACID	65850	4.00E+000 I					1.5E+005 N	1.5E+004 N	5.4E+003 N	8.2E+006 N	3.1E+005 N		
BENZYL ALCOHOL	100516	3.00E-001 H					1.1E+004 N	1.1E+003 N	4.1E+002 N	6.1E+005 N	2.3E+004 N	4.4E+000	[illegible] N
BENZYL CHLORIDE	100447		0.17 I			y	6.2E-002 C	3.7E-002 C	1.9E-002 C	3.4E+001 C	3.8E+000 C	1.9E-005	3.7E-004 C
BERYLLIUM	7440417	2.00E-003 I		5.7E-006 I	8.40E+000 I		7.3E+001 N	7.5E-004 C	2.7E+000 N	4.1E+003 N	1.6E+002 N	5.8E+001	1.2E+003 N
BIPHENYL	92524	5.00E-002 I				y	3.0E+002 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N	4.8E+000	9.6E+001 N
BIS(2-CHLOROETHYL)ETHER	111444		1.10E+000 I		1.10E+000 I	y	9.6E-003 C	5.7E-003 C	2.9E-003 C	5.2E+000 C	5.8E-001 C	2.2E-006	4.4E-005 C
BIS(2-CHLOROISOPROPYL)ETHER	108601	4.00E-002 I	7.00E-002 H		3.50E-002 H	y	2.6E-001 C	1.8E-001 C	4.5E-002 C	8.2E+001 C	9.1E+000 C	8.4E-005	1.7E-003 C
BIS(CHLOROMETHYL)ETHER	542881		2.20E+002 I		2.20E+002 I	y	4.8E-005 C	2.8E-005 C	1.4E-005 C	2.6E-002 C	2.9E-003 C	9.7E-009	1.9E-007 C
BIS(2-ETHYLHEXYL)PHTHALATE	117817	2.00E-002 I	1.40E-002 I		1.40E-002 E		4.8E+000 C	4.5E-001 C	2.3E-001 C	4.1E+002 C	4.6E+001 C	1.4E+002	[illegible]+003 C
BORON	7440428	9.00E-002 I		5.70E-003 H			3.3E+003 N	2.1E+001 N	1.2E+002 N	1.8E+005 N	7.0E+003 N		

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Basis: C = Carcinogenic effects N = Noncarcinogenic effects ! = RBC at HI of 0.1 < RBC-c

Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Risk based concentrations: Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil: Industrial mg/kg	Soil: Residential mg/kg	Region III SSLs, Soil for groundwater migration: DAF 1 mg/kg	DAF 20 mg/kg
BROMODICHLOROMETHANE	75274	2.00E-002 I	6.20E-002 I			y	1.7E-001 C	1.0E-001 C	5.1E-002 C	9.2E+001 C	1.0E+001 C	5.4E-005	1.1E-003 C
BROMOETHENE	593602			8.6E-004 I	1.10E-001 H	y	1.1E-001 C	5.7E-002 C				5.4E-005	1.1E-003 C
BROMOFORM	75252	2.00E-002 I	7.90E-003 I		3.90E-003 I		8.5E+000 C	1.6E+000 C	4.0E-001 C	7.2E+002 C	8.1E+001 C	2.0E-001	4.1E+000 C
BROMOMETHANE	74839	1.40E-003 I		1.40E-003 I		y	8.5E+000 N	5.1E+000 N	1.9E+000 N	2.9E+003 N	1.1E+002 N	2.1E-003	4.1E-002 N
BROMOPHOS	2104963	5.00E-003 H					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
1,3-BUTADIENE	106990				1.80E+000 H	y	7.0E-003 C	3.5E-003 C				3.9E-006	7.8E-005 C
1-BUTANOL	71363	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	7.8E-001	1.6E+001 N
BUTYLBENZYLPHTHALATE	85687	2.00E-001 I					7.3E+003 N	7.3E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N	8.4E+002	1.7E+004 N
BUTYLATE	2008415	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
N-BUTYLBENZENE	104518	1.00E-002 E				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
SEC-BUTYLBENZENE	135988	1.00E-002 E				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
TERT-BUTYLBENZENE	98066	1.00E-002 E				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
**CADMIUM-WATER	7440439	5.00E-004 I		5.7E-005 E	6.30E+000 I		1.8E+001 N	9.9E-004 C	6.8E-001 N	1.0E+003 N	3.9E+001 N	1.4E+000	2.7E+001 N
**CADMIUM-FOOD	7440439	1.00E-003 I		5.7E-005 E	6.30E+000 I		3.7E+001 N	9.9E-004 C	1.4E+000 N	2.0E+003 N	7.8E+001 N	2.7E+000	5.5E+001 N
CAPROLACTAM	105602	5.00E-001 I					1.8E+004 N	1.8E+003 N	6.8E+002 N	1.0E+006 N	3.9E+004 N		
CARBARYL	63252	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	1.5E+000	3.0E+001 N
CARBON DISULFIDE	75150	1.00E-001 I		2.00E-001 I		y	1.0E+003 N	7.3E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	9.5E-001	1.9E+001 N
CARBON TETRACHLORIDE	56235	7.00E-004 I	1.30E-001 I	5.71E-004 E	5.30E-002 I	y	1.6E-001 C	1.2E-001 C	2.4E-002 C	4.4E+001 C	4.9E+000 C	1.1E-004	2.1E-003 C
CARBOSULFAN	55285148	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
CHLORAL	75876	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
CHLORANIL	118752		4.00E-001 H				1.7E-001 C	1.6E-002 C	7.9E-003 C	1.4E+001 C	1.6E+000 C		
CHLORDANE	57749	5.00E-004 I	3.5E-001 I	2.00E-004 I	3.5E-001 I		1.9E-001 C	1.8E-002 C	9.0E-003 C	1.6E+001 C	1.8E+000 C	4.6E-002	9.2E-001 C
**CHLORINE	7782505	1.00E-001 I		5.7E-005 E		y	4.2E-001 N	2.1E-001 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
CHLORINE DIOXIDE	10049044			5.70E-005 I		y	4.2E-001 N	2.1E-001 N					
CHLOROACETIC ACID	79118	2.00E-003 H					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
4-CHLOROANILINE	106478	4.00E-003 I					1.5E+002 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N	4.8E-002	9.7E-001 N
CHLOROBENZENE	108907	2.00E-002 I		1.7E-002 E		y	1.1E+002 N	6.2E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	4.0E-002	[illegible]
CHLOROBENZILATE	510156	2.00E-002 I	2.70E-001 H		2.70E-001 H		2.5E-001 C	2.3E-002 C	1.2E-002 C	2.1E+001 C	2.4E+000 C	1.3E-003	2.7E-002 C
P-CHLOROBENZOIC ACID	74113	2.00E-001 H					7.3E+003 N	7.3E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N		
2-CHLORO-1,3-BUTADIENE	126998	2.00E-002 A		2.00E-003 H		y	1.4E+001 N	7.3E+000 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	6.0E-003	1.2E-001 N
1-CHLOROBUTANE	109693	4.00E-001 H				y	2.4E+003 N	1.5E+003 N	5.4E+002 N	8.2E+005 N	3.1E+004 N	1.0E+000	[illegible]
1-CHLORO-1,1-DIFLUOROETHANE	75683			1.40E+001 I		y	1.0E+005 N	5.1E+004 N				7.0E+001	1.4E+003 N
CHLORODIFLUOROMETHANE	75456			1.40E+001 I		y	1.0E+005 N	5.1E+004 N				7.0E+001	1.4E+003 N
CHLOROETHANE	75003	4.00E-001 E	2.90E-003 E	2.90E+000 I		y	3.6E+000 C	2.2E+000 C	1.1E+000 C	2.0E+003 C	2.2E+002 C	9.6E-004	1.9E-002 C
CHLOROFORM	67663	1.00E-002 I	6.10E-003 I	8.6E-005 E	8.10E-002 I	y	1.5E-001 C !	7.7E-002 C !	5.2E-001 C	9.4E+002 C	1.0E+002 C	4.5E-005	8.9E-004 C
CHLOROMETHANE	74873		1.30E-002 H	8.6E-002 E	3.5E-003 E	y	2.1E+000 C	1.8E+000 C	2.4E-001 C	4.4E+002 C	4.9E+001 C	5.2E-004	1.0E-002 C
4-CHLORO-2-METHYLANILINE	95692		5.80E-001 H				1.2E-001 C	1.1E-002 C	5.4E-003 C	9.9E+000 C	1.1E+000 C		
BETA-CHLORONAPHTHALENE	91587	8.00E-002 I				y	4.9E+002 N	2.9E+002 N	1.1E+002 N	1.6E+005 N	6.3E+003 N	1.6E+000	3.2E+001 N
O-CHLORONITROBENZENE	88733		2.50E-002 H			y	4.2E-001 C	2.5E-001 C	1.3E-001 C	2.3E+002 C	2.6E+001 C		
P-CHLORONITROBENZENE	100005		1.80E-002 H			y	5.9E-001 C	3.5E-001 C	1.8E-001 C	3.2E+002 C	3.5E+001 C		
2-CHLOROPHENOL	95578	5.00E-003 I				y	3.0E+001 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
2-CHLOROPROPANE	75296			2.90E-002 H		y	2.1E+002 N	1.1E+002 N				6.6E-002	1.3E+000 N
O-CHLOROTOLUENE	95498	2.00E-002 I				y	1.2E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	6.5E-002	1.3E+000 N
CHLORPYRIFOS	2921882	3.00E-003 I					1.1E+002 N	1.1E+001 N	4.1E+000 N	6.1E+003 N	2.3E+002 N	3.2E+000	6.3E+001 N
CHLORPYRIFOS-METHYL	5598130	1.00E-002 H					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		

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Basis: C = Carcinogenic effects N = Noncarcinogenic effects I = RBC at HI of 0.1 < RBC-c

							Risk-based concentrations					Region III SSLs	
							Tap	Ambient		Soil		Soil, for groundwater migration	
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	water ug/l	air ug/m3	Fish mg/kg	Industrial mg/kg	Residential mg/kg	DAF 1 mg/kg	DAF 20 mg/kg
CHROMIUM III	16065831	1.50E+000 I					5.5E+004 N	5.5E+003 N	2.0E+003 N	3.1E+006 N	1.2E+005 N	9.9E+007	2.0E+009 N
CHROMIUM VI	18540299	3.00E-003 I		3.00E-005 I	4.10E+001 H		1.1E+002 N	1.5E-004 C	4.1E+000 N	6.1E+003 N	2.3E+002 N	2.1E+000	4.2E+001 N
COBALT	7440484	6.00E-002 E					2.2E+003 N	2.2E+002 N	8.1E+001 N	1.2E+005 N	4.7E+003 N		
COKE OVEN EMISSIONS (COAL TAR)	8007452				2 2 I			2.8E-003 C					
COPPER	7440508	4.00E-002 H					1.5E+003 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N	5.3E+002	1.1E+004 N
CROTONALDEHYDE	123739		1.90E+000 H			y	5.6E-003 C	3.3E-003 C	1.7E-003 C	3.0E+000 C	3.4E-001 C	1.5E-005	[illegible]
CUMENE	98828	1.00E-001 I		1.10E-001 I		y	6.6E+002 N	4.0E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	3.2E+000	6.4E+001 N
CYANIDE (FREE)	57125	2.00E-002 I					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	7.4E+000	1.5E+002 N
CALCIUM CYANIDE	592018	4E-002 I					1.5E+003 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N		
COPPER CYANIDE	544923	5.00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
CYANAZINE	21725462	2.00E-003 H	8.40E-001 H				8.0E-002 C	7.5E-003 C	3.8E-003 C	6.8E+000 C	7.6E-001 C	2.6E-005	[illegible]
CYANOGEN	460195	4.00E-002 I				y	2.4E+002 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N		
CYANOGEN BROMIDE	506683	9.00E-002 I					3.3E+003 N	3.3E+002 N	1.2E+002 N	1.8E+005 N	7.0E+003 N		
CYANOGEN CHLORIDE	506774	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
HYDROGEN CYANIDE	74908	2.00E-002 I		8.60E-004 I		y	6.2E+000 N	3.1E+000 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	1.1E-001	[illegible]
POTASSIUM CYANIDE	151508	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
POTASSIUM SILVER CYANIDE	506616	2.00E-001 I					7.3E+003 N	7.3E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N		
SILVER CYANIDE	506649	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	3.1E+001	[illegible]
SODIUM CYANIDE	143339	4.00E-002 I					1.5E+003 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N		
**THIOCYANATE		5.00E-002 E					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
ZINC CYANIDE	557211	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N	1.1E+002	[illegible]
CYCLOHEXANONE	108941	5.00E+000 I					1.8E+005 N	1.8E+004 N	6.8E+003 N	1.0E+007 N	3.9E+005 N	6.1E+001	1.2E+003 N
CYHALOTHRIN/KARATE	68085858	5.00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
CYPERMETHRIN	52315078	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
DACTHAL	1861321	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
DALAPON	75990	3.00E-002 I					1.1E+003 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N	3.5E-001	7.1E+000 N
DDD	72548		2.40E-001 I				2.8E-001 C	2.6E-002 C	1.3E-002 C	2.4E+001 C	2.7E+000 C	5.6E-001	1.1E+001 C
DDE	72559		3.40E-001 I				2.0E-001 C	1.8E-002 C	9.3E-003 C	1.7E+001 C	1.9E+000 C	1.8E+000	3.5E+001 C
DDT	50293	5.00E-004 I	3.40E-001 I		3.40E-001 I		2.0E-001 C	1.8E-002 C	9.3E-003 C	1.7E+001 C	1.9E+000 C	5.8E-002	[illegible]
DIAZINON	333415	9.00E-004 H					3.3E+001 N	3.3E+000 N	1.2E+000 N	1.8E+003 N	7.0E+001 N	2.1E-002	[illegible]
DIBENZOFURAN	132649	4.00E-003 E				y	2.4E+001 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N	3.8E-001	[illegible]
1,4-DIBROMOBENZENE	106376	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
DIBROMOCHLOROMETHANE	124481	2.00E-002 I	8.40E-002 I			y	1.3E-001 C	7.5E-002 C	3.8E-002 C	6.8E+001 C	7.6E+000 C	4.1E-005	8.3E-004 C
1,2-DIBROMO-3-CHLOROPROPANE	96128		1.40E+000 H	5.70E-005 I	2.40E-003 H	y	4.7E-002 C I	2.1E-001 N	2.3E-003 C	4.1E+000 C	4.6E-001 C	4.4E-005	[illegible]
1,2-DIBROMOETHANE	106934		8.50E+001 I	5.70E-005 H	7.60E-001 I	y	7.5E-004 C	8.2E-003 C	3.7E-005 C	6.7E-002 C	7.5E-003 C	4.3E-007	[illegible]
DIBUTYLPHTHALATE	84742	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	2.5E+002	[illegible]
DICAMBA	1918009	3.00E-002 I					1.1E+003 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N	2.2E-001	[illegible]
**1,2-DICHLOROBENZENE	95501	9.00E-002 I				y	5.5E+002 N	3.3E+002 N	1.2E+002 N	1.8E+005 N	7.0E+003 N	4.6E-001	[illegible]
1,3-DICHLOROBENZENE	541731	9.00E-004 E				y	5.5E+000 N	3.3E+000 N	1.2E+000 N	1.8E+003 N	7.0E+001 N	4.4E-003	8.7E-002 N
1,4-DICHLOROBENZENE	106467	3.00E-002 E	2.40E-002 H	2.29E-001 I	2.2E-002 E	y	4.7E-001 C	2.8E-001 C	1.3E-001 C	2.4E+002 C	2.7E+001 C	3.6E-004	7.1E-003 C
3,3'-DICHLOROBENZIDINE	91941		4.50E-001 I				1.5E-001 C	1.4E-002 C	7.0E-003 C	1.3E+001 C	1.4E+000 C	2.5E-004	4.9E-003 C
1,4-DICHLORO-2-BUTENE	764410				9.30E+000 H	y	1.3E-003 C	6.7E-004 C				4.0E-007	8.0E-006 C
DICHLORODIFLUOROMETHANE	75718	2.00E-001 I		5.00E-002 A		y	3.5E+002 N	1.8E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N	5.5E-001	1.1E+001 N
1,1-DICHLOROETHANE	75343	1.00E-001 H		1.40E-001 A		y	8.0E+002 N	5.1E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	2.3E-001	4.5E+000 N
1,2-DICHLOROETHANE	107062	3.00E-002 E	9.10E-002 I	1.40E-003 E	9.10E-002 I	y	1.2E-001 C	6.9E-002 C	3.5E-002 C	6.3E+001 C	7.0E+000 C	5.2E-005	1.0E-003 C

Sources: I = IRIS H = HEAST A = HEAST Alternate W = Withdrawn from IRIS or HEAST
E = EPA-NCEA provisional value O = other

Basis: C = Carcinogenic effects N = Noncarcinogenic effects ! = RBC at HI of 0.1 < RBC-c

Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Risk-based concentrations: Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg	Region III SSLs Soil, for groundwater migration: DAF 1 mg/kg	DAF 20 mg/kg
1,1-DICHLOROETHENE	75354	9.00E-003 I	6.00E-001 I		1.75E-001 I	y	4.4E-002 C	3.6E-002 C	5.3E-003 C	9.5E+000 C	1.1E+000 C	1.8E-005	[illegible] C
CIS-1,2-DICHLOROETHENE	156592	1.00E-002 H				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N	1.7E-002	[illegible] N
TRANS-1,2-DICHLOROETHENE	156605	2.00E-002 I				y	1.2E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	4.1E-002	8.2E-001 N
TOTAL 1,2-DICHLOROETHENE	540590	9.00E-003 H				y	5.5E+001 N	3.3E+001 N	1.2E+001 N	1.8E+004 N	7.0E+002 N	1.9E-002	3.7E-001 N
2,4-DICHLOROPHENOL	120832	3.00E-003 I					1.1E+002 N	1.1E+001 N	4.1E+000 N	6.1E+003 N	2.3E+002 N	6.0E-002	1.2E+000 N
2,4-D	94757	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N	4.5E-00[illegible]	9.0E+000 N
4-(2,4-DICHLOROPHENOXY)BUTYRIC ACID	94826	8E-003 I					2.9E+002 N	2.9E+001 N	1.1E+001 N	1.6E+004 N	6.3E+002 N		
1,2-DICHLOROPROPANE	78875		6.80E-002 H	1.14E-003 I		y	1.6E-001 C	9.2E-002 C	4.6E-002 C	8.4E+001 C	9.4E+000 C	1.0E-004	[illegible]E-003 C
2,3-DICHLOROPROPANOL	616239	3.00E-003 I					1.1E+002 N	1.1E+001 N	4.1E+000 N	6.1E+003 N	2.3E+002 N		
1,3-DICHLOROPROPENE	542756	3.00E-004 I	1.80E-001 H	5.71E-003 I	1.30E-001 H	y	7.7E-002 C	4.8E-002 C	1.8E-002 C	3.2E+001 C	3.5E+000 C !	2.7E-005	5.5E-004 C
DICHLORVOS	62737	5E-004 I	0.29 I	1.43E-004 I			2.3E-001 C	2.2E-002 C	1.1E-002 C	2.0E+001 C	2.2E+000 C	5.5E-005	1.1E-003 C
DICOFOL	115322		4.4E-001 W				1.5E-001 C	1.4E-002 C	7.2E-003 C	1.3E+001 C	1.5E+000 C	9.3E-004	1.9E-002 C
DICYCLOPENTADIENE	77736	3E-002 H		6.00E-005 A		y	4.4E-001 N	2.2E-001 N	4.1E+001 N	6.1E+004 N	2.3E+003 N		
DIELDRIN	60571	5.00E-005 I	1.60E+001 I		1.60E+001 I		4.2E-003 C	3.9E-004 C	2.0E-004 C	3.6E-001 C	4.0E-002 C	1.1E-004	2.2E-003 C
DIESEL EMISSIONS				1.40E-003 I				5.1E+000 N					
DIETHYLPHTHALATE	84662	8.00E-001 I					2.9E+004 N	2.9E+003 N	1.1E+003 N	1.6E+006 N	6.3E+004 N	2.3E+001	[illegible]E+002 N
DIETHYLENE GLYCOL, MONOBUTYL ETHER	112345			5.70E-003 H				2.1E+001 N					
DIETHYLENE GLYCOL, MONOETHYL ETHER	111900	2.00E+000 H					7.3E+004 N	7.3E+003 N	2.7E+003 N	4.1E+006 N	1.6E+005 N		
DI(2-ETHYLHEXYL)ADIPATE	103231	6.00E-001 I	1.20E-003 I				5.6E+001 C	5.2E+000 C	2.6E+000 C	4.8E+003 C	5.3E+002 C		
DIETHYLSTILBESTROL	56531		4.70E+003 H				1.4E-005 C	1.3E-006 C	6.7E-007 C	1.2E-003 C	1.4E-004 C		
DIFENZOQUAT (AVENGE)	43222486	8.00E-002 I					2.9E+003 N	2.9E+002 N	1.1E+002 N	1.6E+005 N	6.3E+003 N		
1,1-DIFLUOROETHANE	75376			1.10E+001 I		y	8.0E+004 N	4.0E+004 N					
DIISOPROPYL METHYLPHOSPHONATE (DIMP)	1445756	8.00E-002 I					2.9E+003 N	2.9E+002 N	1.1E+002 N	1.6E+005 N	6.3E+003 N		
3,3'-DIMETHOXYBENZIDINE	119904		1.40E-002 H				4.8E+000 C	4.5E-001 C	2.3E-001 C	4.1E+002 C	4.6E+001 C		
DIMETHYLAMINE	124403			5.70E-006 W		y	4.2E-002 N	2.1E-002 N				8.5E-006	[illegible]
2,4-DIMETHYLANILINE HYDROCHLORIDE	21436964		5.80E-001 H				1.2E-001 C	1.1E-002 C	5.4E-003 C	9.9E+000 C	1.1E+000 C		
2,4-DIMETHYLANILINE	95681		7.50E-001 H				8.9E-002 C	8.3E-003 C	4.2E-003 C	7.6E+000 C	8.5E-001 C		
N,N-DIMETHYLANILINE	121697	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
3,3'-DIMETHYLBENZIDINE	119937		9.20E+000 H				7.3E-003 C	6.8E-004 C	3.4E-004 C	6.2E-001 C	6.9E-002 C		
1,1-DIMETHYLHYDRAZINE	57147		2.60E+000 W		3.50E+000 W		2.6E-002 C	1.8E-003 C	1.2E-003 C	2.2E+000 C	2.5E-001 C		
1,2-DIMETHYLHYDRAZINE	540738		3.70E+001 W		3.70E+001 W		1.8E-003 C	1.7E-004 C	8.5E-005 C	1.5E-001 C	1.7E-002 C		
2,4-DIMETHYLPHENOL	105679	2.00E-002 I					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	3.4E-001	[illegible] N
2,6-DIMETHYLPHENOL	576261	6.00E-004 I					2.2E+001 N	2.2E+000 N	8.1E-001 N	1.2E+003 N	4.7E+001 N		
3,4-DIMETHYLPHENOL	95658	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N		
DIMETHYLPHTHALATE	131113	1.00E+001 W					3.7E+005 N	3.7E+004 N	1.4E+004 N	2.0E+007 N	7.8E+005 N		
1,2-DINITROBENZENE	528290	4.00E-004 H					1.5E+001 N	1.5E+000 N	5.4E-001 N	8.2E+002 N	3.1E+001 N		
1,3-DINITROBENZENE	99650	1.00E-004 I					3.7E+000 N	3.7E-001 N	1.4E-001 N	2.0E+002 N	7.8E+000 N	1.8E-00[illegible]	[illegible] N
1,4-DINITROBENZENE	100254	4.00E-004 H					1.5E+001 N	1.5E+000 N	5.4E-001 N	8.2E+002 N	3.1E+001 N		
4,6-DINITRO-O-CYCLOHEXYL PHENOL	131895	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
4,6-DINITRO-2-METHYLPHENOL	534521	1.00E-004 E					3.7E+000 N	3.7E-001 N	1.4E-001 N	2.0E+002 N	7.8E+000 N		
2,4-DINITROPHENOL	51285	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
DINITROTOLUENE MIX			6.80E-001 I				9.8E-002 C	9.2E-003 C	4.6E-003 C	8.4E+000 C	9.4E-001 C		
2,4-DINITROTOLUENE	121142	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N	2.9E-002	5.7E-001 N
2,6-DINITROTOLUENE	606202	1.00E-003 H					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N	1.2E-002	2.5E-001 N
DINOSEB	88857	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N	8.7E-003	1.7E-001 N

Sources: I = IRIS H = HEAST A = HEAST Alternate W = Withdrawn from IRIS or HEAST E = EPA-NCEA provisional value O = other

Basis: C = Carcinogenic effects N = Noncarcinogenic effects ! = RBC at HI of 0.1 < RBC c

							Risk-based concentrations					Region III SSLs	
							Tap water	Ambient air	Fish	Soil Industrial	Residential	Soil, for groundwater migration DAF 1	DAF 20
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	ug/l	ug/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
DIOCTYLPHTHALATE	117840	2.00E-002 H					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	1.2E+005	2.4E+006 N
1,4-DIOXANE	123911		1.10E-002 I				6.1E+000 C	5.7E-001 C	2.9E-001 C	5.2E+002 C	5.8E+001 C	1.3E-003	2.6E-002 C
DIPHENYLAMINE	122394	2.50E-002 I					9.1E+002 N	9.1E+001 N	3.4E+001 N	5.1E+004 N	2.0E+003 N	1.3E+000	2.5E+001 N
1,2-DIPHENYLHYDRAZINE	122667		8.00E-001 I		8.00E-001 I		8.4E-002 C	7.8E-003 C	3.9E-003 C	7.2E+000 C	8.0E-001 C	1.3E-004	2.5E-003 C
DIQUAT	85007	2.20E-003 I					8.0E+001 N	8.0E+000 N	3.0E+000 N	4.5E+003 N	1.7E+002 N	1.7E-002	3.4E-001 N
DISULFOTON	298044	4.00E-005 I					1.5E+000 N	1.5E-001 N	5.4E-002 N	8.2E+001 N	3.1E+000 N	3.2E-003	6.4E-002 N
1,4-DITHIANE	505293	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
DIURON	330541	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N	5.8E-002	1.2E+000 N
ENDOSULFAN	115297	6.00E-003 I					2.2E+002 N	2.2E+001 N	8.1E+000 N	1.2E+004 N	4.7E+002 N	9.8E-001	2.0E+001 N
ENDRIN	72208	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N	2.7E-001	5.4E+000 N
EPICHLOROHYDRIN	106898	2.00E-003 H	9.90E-003 I	2.86E-004 I	4.20E-003 I	y	2.0E+000 N	1.0E+000 N	3.2E-001 C	5.8E+002 C !	6.5E+001 C !	4.2E-004	8.4E-003 N
ETHION	563122	5.00E-004 I					1.8E+001 N	1.8E+000 N	6.8E-001 N	1.0E+003 N	3.9E+001 N	3.2E-001	6.4E+000 N
2-ETHOXYETHANOL	110805	4.00E-001 H		5.70E-002 I			1.5E+004 N	2.1E+002 N	5.4E+002 N	8.2E+005 N	3.1E+004 N	3.3E+000	6.5E+001 N
ETHYL ACETATE	141786	9.00E-001 I				y	5.5E+003 N	3.3E+003 N	1.2E+003 N	1.8E+006 N	7.0E+004 N	1.7E+000	3.5E+001 N
ETHYLBENZENE	100414	1.00E-001 I		2.90E-001 I		y	1.3E+003 N	1.1E+003 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	7.5E-001	1.5E+001 N
ETHYLENE DIAMINE	107153	2.00E-002 H					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N		
ETHYLENE GLYCOL	107211	2.00E+000 I					7.3E+004 N	7.3E+003 N	2.7E+003 N	4.1E+006 N	1.6E+005 N	1.5E+001	3.0E+002 N
ETHYLENE GLYCOL, MONOBUTYL ETHER	111762			5.70E-003 H				2.1E+001 N					
ETHYLENE OXIDE	75218		1.00E+000 H		3.50E-001 H	y	2.3E-002 C	1.8E-002 C	3.2E-003 C	5.7E+000 C	6.4E-001 C	4.8E-006	[illegible] C
ETHYLENE THIOUREA	96457	8.00E-005 I	1.1E-001 H				6.1E-001 C !	5.7E-002 C !	2.9E-002 C !	5.2E+001 C !	5.8E+000 C !		
ETHYL ETHER	60297	2.00E-001 I				y	1.2E+003 N	7.3E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N	4.2E-001	[illegible] N
ETHYL METHACRYLATE	97632	9.00E-002 H				y	5.5E+002 N	3.3E+002 N	1.2E+002 N	1.8E+005 N	7.0E+003 N	1.0E+000	2.1E+001 N
FENAMIPHOS	22224926	2.50E-004 I					9.1E+000 N	9.1E-001 N	3.4E-001 N	5.1E+002 N	2.0E+001 N	7.8E-003	1.6E-001 N
FLUOMETURON	2164172	1.30E-002 I					4.7E+002 N	4.7E+001 N	1.8E+001 N	2.7E+004 N	1.0E+003 N		
FLUORINE	7782414	6.00E-002 I					2.2E+003 N	2.2E+002 N	8.1E+001 N	1.2E+005 N	4.7E+003 N		
FOMESAFEN	72178020		1.90E-001 I				3.5E-001 C	3.3E-002 C	1.7E-002 C	3.0E+001 C	3.4E+000 C		
FONOFOS	944229	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N	1.8E-001	[illegible] N
FORMALDEHYDE	50000	2.00E-001 I			4.50E-002 I		7.3E+003 N	1.4E-001 C	2.7E+002 N	4.1E+005 N	1.6E+004 N	1.5E+000	3.0E+001 N
FORMIC ACID	64186	2.00E+000 H					7.3E+004 N	7.3E+003 N	2.7E+003 N	4.1E+006 N	1.6E+005 N		
FURAN	110009	1.00E-003 I				y	6.1E+000 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N	1.5E-003	[illegible] N
FURAZOLIDONE	67458		3.80E+000 H				1.8E-002 C	1.6E-003 C	8.3E-004 C	1.5E+000 C	1.7E-001 C		
FURFURAL	98011	3.00E-003 I		1.00E-002 A			1.1E+002 N	3.7E+001 N	4.1E+000 N	6.1E+003 N	2.3E+002 N	2.3E-002	[illegible] N
GLYCIDALDEHYDE	765344	4.00E-004 I		2.90E-004 H			1.5E+001 N	1.1E+000 N	5.4E-001 N	8.2E+002 N	3.1E+001 N		
GLYPHOSATE	1071836	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N	2.6E+001	[illegible] N
HEPTACHLOR	76448	5.00E-004 I	4.50E+000 I		4.50E+000 I		1.5E-002 C	1.4E-003 C	7.0E-004 C	1.3E+000 C	1.4E-001 C	4.2E-002	[illegible] C
HEPTACHLOR EPOXIDE	1024573	1.30E-005 I	9.10E+000 I		9.10E+000 I		7.4E-003 C	6.9E-004 C	3.5E-004 C	6.3E-001 C	7.0E-002 C	1.2E-003	[illegible] C
HEXABROMOBENZENE	87821	2.00E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
HEXACHLOROBENZENE	118741	8.00E-004 I	1.60E+000 I		1.60E+000 I		4.2E-002 C	3.9E-003 C	2.0E-003 C	3.6E+000 C	4.0E-001 C	2.6E-003	5.2E-002 C
HEXACHLOROBUTADIENE	87683	2.00E-004 H	7.80E-002 I		7.80E-002 I		8.6E-001 C !	8.0E-002 C !	4.0E-002 C !	7.3E+001 C !	8.2E+000 C !	9.2E-002	1.8E+000 C
ALPHA-HCH	319846		6.30E+000 I		6.30E+000 I		1.1E-002 C	9.9E-004 C	5.0E-004 C	9.1E-001 C	1.0E-001 C	4.5E-005	8.9E-004 C
BETA-HCH	319857		1.80E+000 I		1.80E+000 I		3.7E-002 C	3.5E-003 C	1.8E-003 C	3.2E+000 C	3.5E-001 C	1.6E-004	3.1E-003 C
GAMMA-HCH (LINDANE)	58899	3.00E-004 I	1.30E+000 H				5.2E-002 C	4.8E-003 C	2.4E-003 C	4.4E+000 C	4.9E-001 C	2.2E-004	4.3E-003 C
TECHNICAL HCH	608731		1.80E+000 I		1.80E+000 I		3.7E-002 C	3.5E-003 C	1.8E-003 C	3.2E+000 C	3.5E-001 C		
HEXACHLOROCYCLOPENTADIENE	77474	7.00E-003 I		2.00E-005 H			2.6E+002 N	7.3E-002 N	9.5E+000 N	1.4E+004 N	5.5E+002 N	1.0E+002	2.0E+003 N
HEXACHLORODIBENZODIOXIN MIX	19408743		6.20E+003 I		4.55E+003 I		1.1E-005 C	1.4E-006 C	5.1E-007 C	9.2E-004 C	1.0E-004 C		

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Basis C = Carcinogenic effects N = Noncarcinogenic effects I = RBC at HI of 0.1 < RBC-c

Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Risk-based concentrations: Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg	Region III SSLs, Soil, for groundwater migration: DAF 1 mg/kg	DAF 20 mg/kg
HEXACHLOROETHANE	67721	1.00E-003 I	1.40E-002 I		1.40E-002 I		4.8E+000 C !	4.5E 001 C !	2.3E-001 C !	4.1E+002 C !	4.6E+001 C !	1.8E-002	[illegible]
HEXACHLOROPHENE	70304	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N	1.0E+002	[illegible]
1,6-HEXAMETHYLENE DIISOCYANATE	822060			2.90E-006 I				1.1E-002 N					
HEXANE	110543	6.00E-002 H		5.71E-002 I		y	3.5E+002 N	2.1E+002 N	8.1E+001 N	1.2E+005 N	4.7E+003 N	6.9E-001	[illegible]
2-HEXANONE	591786	4.00E-002 E		1.4E-003 E			1.5E+003 N	5.1E+000 N	5.4E+001 N	8.2E+004 N	3.1E+003 N		
HEXAZINONE	51235042	3.30E-002 I					1.2E+003 N	1.2E+002 N	4.5E+001 N	6.7E+004 N	2.6E+003 N		
HMX	2691410	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
HYDRAZINE	302012		3.00E+000 I		1.70E+001 I		2.2E-002 C	3.7E-004 C	1.1E-003 C	1.9E+000 C	2.1E-001 C		
HYDROGEN CHLORIDE	7647010			5.70E-003 I				2.1E+001 N					
HYDROGEN SULFIDE	7783064	3.00E-003 I		2.85E-004 I			1.1E+002 N	1.0E+000 N	4.1E+000 N	6.1E+003 N	2.3E+002 N		
HYDROQUINONE	123319	4.00E-002 H					1.5E+003 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N		
IRON	7439896	3.00E-001 E					1.1E+004 N	1.1E+003 N	4.1E+002 N	6.1E+005 N	2.3E+004 N		
ISOBUTANOL	78831	3.00E-001 I				y	1.8E+003 N	1.1E+003 N	4.1E+002 N	6.1E+005 N	2.3E+004 N	5.9E-001	[illegible]
ISOPHORONE	78591	2.00E-001 I	9.50E-004 I				7.0E+001 C	6.6E+000 C	3.3E+000 C	6.0E+003 C	6.7E+002 C	2.1E-002	[illegible]
ISOPROPALIN	33820530	1.50E-002 I					5.5E+002 N	5.5E+001 N	2.0E+001 N	3.1E+004 N	1.2E+003 N		
ISOPROPYL METHYL PHOSPHONIC ACID	1832548	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
TETRAETHYLLEAD	78002	1.00E-007 I					3.7E-003 N	3.7E-004 N	1.4E-004 N	2.0E-001 N	7.8E-003 N	4.6E-005	[illegible]
LITHIUM	7439932	2.00E-002 E					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N		
MALATHION	121755	2.00E-002 I					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	4.0E-001	[illegible]
MALEIC ANHYDRIDE	108316	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
MANGANESE-NONFOOD	7439965	2.00E-002 I		1.43E-005 I			7.3E+002 N	5.2E-002 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	4.8E+001	[illegible]
MANGANESE-FOOD	7439965	1.40E-001 I		1.43E-005 I			5.1E+003 N	5.2E-002 N	1.9E+002 N	2.9E+005 N	1.1E+004 N	3.3E+002	[illegible]
MEPHOSFOLAN	950107	9.00E-005 H					3.3E+000 N	3.3E-001 N	1.2E-001 N	1.8E+002 N	7.0E+000 N		
MEPIQUAT CHLORIDE	24307264	3.00E-002 I					1.1E+003 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N		
MERCURIC CHLORIDE	7487947	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N		
MERCURY (INORGANIC)	7439976			8.60E-005 I				3.1E-001 N					
METHYLMERCURY	22967926	1.00E-004 I					3.7E+000 N	3.7E-001 N	1.4E-001 N	2.0E+002 N	7.8E+000 N		
METHACRYLONITRILE	126987	1.00E-004 I		2.00E-004 A		y	1.0E+000 N	7.3E-001 N	1.4E-001 N	2.0E+002 N	7.8E+000 N	2.1E-004	[illegible]
METHANOL	67561	5.00E-001 I					1.8E+004 N	1.8E+003 N	6.8E+002 N	1.0E+006 N	3.9E+004 N	3.8E+000	[illegible]
METHIDATHION	950378	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N		
METHOXYCHLOR	72435	5.00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N	1.5E+001	[illegible]
METHYL ACETATE	79209	1.00E+000 H				y	6.1E+003 N	3.7E+003 N	1.4E+003 N	2.0E+006 N	7.8E+004 N	1.2E+000	[illegible]
METHYL ACRYLATE	96333	3.00E-002 A				y	1.8E+002 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N	5.0E-001	[illegible]
2-METHYLANILINE	95534		2.40E-001 H				2.8E-001 C	2.6E-002 C	1.3E-002 C	2.4E+001 C	2.7E+000 C	2.8E-004	[illegible]
4-(2-METHYL-4-CHLOROPHENOXY) BUTYRIC ACID	94815	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
2-METHYL-4-CHLOROPHENOXYACETIC ACID (MCPA)	94746	5.00E-004 I					1.8E+001 N	1.8E+000 N	6.8E-001 N	1.0E+003 N	3.9E+001 N		
2-(2-METHYL-4-CHLOROPHENOXY)PROPIONIC ACID (MCPP)	93652	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N		
METHYLCYCLOHEXANE	108872			8.60E-001 H		y	6.3E+003 N	3.1E+003 N					
METHYLENE BROMIDE	74953	1.00E-002 A				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N	1.5E-002	3.0E-001 N
METHYLENE CHLORIDE	75092	6.00E-002 I	7.50E-003 I	8.60E-001 H	1.65E-003 I	y	4.1E+000 C	3.8E+000 C	4.2E-001 C	7.6E+002 C	8.5E+001 C	9.5E-004	1.9E-002 C
4,4'-METHYLENE BIS(2-CHLOROANILINE)	101144	7.00E-004 H	1.30E-001 H		1.30E-001 H		5.2E-001 C	4.8E-002 C	2.4E-002 C	4.4E+001 C	4.9E+000 C		
4,4'-METHYLENE BIS(N,N'-DIMETHYL)ANILINE	101611		4.60E-002 I				1.5E+000 C	1.4E-001 C	6.9E-002 C	1.2E+002 C	1.4E+001 C		
4,4'-METHYLENEDIPHENYL ISOCYANATE	101688			1.7E-004 I				6.2E-001 N					
METHYL ETHYL KETONE (2-BUTANONE)	78933	6.00E-001 I		2.86E-001 I		y	1.9E+003 N	1.0E+003 N	8.1E+002 N	1.2E+006 N	4.7E+004 N	4.0E-001	7.9E+000 N
METHYL HYDRAZINE	60344		1.10E+000 W				6.1E 002 C	5.7E 003 C	2.9E 003 C	5.2E+000 C	5.8E-001 C		

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							Risk-based concentrations					Region III SSLs	
												Soil, for groundwater migration	
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Soil Residential mg/kg	DAF 1 mg/kg	DAF 20 mg/kg
METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANONE)	108101	8.00E-002 H		2.00E-002 A		y	1.4E+002 N	7.3E+001 N	1.1E+002 N	1.6E+005 N	6.3E+003 N	6.5E-002	1.3E+000 N
METHYL METHACRYLATE	80626	1.40E+000 I		2.00E-001 I		y	1.4E+003 N	7.3E+002 N	1.9E+003 N	2.9E+006 N	1.1E+005 N	3.2E-001	6.5E+000 N
2-METHYL-5-NITROANILINE	99558		3.30E-002 H				2.0E+000 C	1.9E-001 C	9.6E-002 C	1.7E+002 C	1.9E+001 C		
METHYL PARATHION	298000	2.50E-004 I					9.1E+000 N	9.1E-001 N	3.4E-001 N	5.1E+002 N	2.0E+001 N	4.3E-003	8.5E-002 N
2-METHYLPHENOL	95487	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
3-METHYLPHENOL	108394	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
4-METHYLPHENOL	106445	5.00E-003 H					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
METHYLSTYRENE MIX	25013154	6.00E-003 A		1.00E-002 A		y	5.5E+001 N	3.7E+001 N	8.1E+000 N	1.2E+004 N	4.7E+002 N	5.1E-002	1.0E+000 N
ALPHA-METHYLSTYRENE	98839	7.00E-002 A				y	4.3E+002 N	2.6E+002 N	9.5E+001 N	1.4E+005 N	5.5E+003 N	4.0E-001	7.9E+000 N
METHYL TERT-BUTYL ETHER	1634044			8.57E-001 I		y	6.3E+003 N	3.1E+003 N				1.4E+000	2.8E+001 N
METOLACHLOR (DUAL)	51218452	1.50E-001 I					5.5E+003 N	5.5E+002 N	2.0E+002 N	3.1E+005 N	1.2E+004 N		
MIREX	2385855	2.00E-004 I					7.3E+000 N	7.3E-001 N	2.7E-001 N	4.1E+002 N	1.6E+001 N		
MOLYBDENUM	7439987	5E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
MONOCHLORAMINE	10599903	1E-001 I		1.00E-001 H			3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
NALED	300765	2E-003 I					7.3E+001 N	7.3E+000 N	2.7E+000 N	4.1E+003 N	1.6E+002 N		
NICKEL REFINERY DUST					8.4E-001 I			7.5E-003 C					
NICKEL	7440020	2.00E-002 I					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N		
NITRATE	14797558	1.60E+000 I					5.8E+004 N	5.8E+003 N	2.2E+003 N	3.3E+006 N	1.3E+005 N		
NITRIC OXIDE	10102439	1.00E-001 W				y	6.1E+002 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
NITRITE	14797650	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
2-NITROANILINE	88744			5.70E-005 H				2.1E-001 N					
NITROBENZENE	98953	5.00E-004 I		6.00E-004 A		y	3.5E+000 N	2.2E+000 N	6.8E-001 N	1.0E+003 N	3.9E+001 N	1.2E-003	2.3E-002 N
NITROFURANTOIN	67209	7.00E-002 H					2.6E+003 N	2.6E+002 N	9.5E+001 N	1.4E+005 N	5.5E+003 N		
NITROFURAZONE	59870		1.50E+000 H				4.5E-002 C	4.2E-003 C	2.1E-003 C	3.8E+000 C	4.3E-001 C		
NITROGEN DIOXIDE	10102440	1.00E+000 W				y	6.1E+003 N	3.7E+003 N	1.4E+003 N	2.0E+006 N	7.8E+004 N		
NITROGLYCERIN	55630		1.4E-002 E				4.8E+000 C	4.5E-001 C	2.3E-001 C	4.1E+002 C	4.6E+001 C		
4-NITROPHENOL	100027	8.00E-003 E					2.9E+002 N	2.9E+001 N	1.1E+001 N	1.6E+004 N	6.3E+002 N	8.7E-002	1.7E+000 N
2-NITROPROPANE	79469			5.70E-003 I	9.40E+000 H	y	1.3E-003 C	6.7E-004 C				3.2E-007	6.4E-006
N-NITROSO-DI-N-BUTYLAMINE	924163		5.40E+000 I		5.60E+000 I	y	1.9E-003 C	1.1E-003 C	5.8E-004 C	1.1E+000 C	1.2E-001 C	1.4E-006	[illegible]
N-NITROSODIETHANOLAMINE	1116547		2.80E+000 I				2.4E-002 C	2.2E-003 C	1.1E-003 C	2.0E+000 C	2.3E-001 C		
N-NITROSODIETHYLAMINE	55185		1.50E+002 I		1.50E+002 I		4.5E-004 C	4.2E-005 C	2.1E-005 C	3.8E-002 C	4.3E-003 C	1.1E-007	2.3E-006 C
N-NITROSODIMETHYLAMINE	62759		5.10E+001 I		5.10E+001 I		1.3E-003 C	1.2E-004 C	6.2E-005 C	1.1E-001 C	1.3E-002 C	2.8E-007	5.7E-006 C
N-NITROSODIPHENYLAMINE	86306		4.90E-003 I				1.4E+001 C	1.3E+000 C	6.4E-001 C	1.2E+003 C	1.3E+002 C	3.8E-002	7.6E-001 C
N-NITROSODIPROPYLAMINE	621647		7.00E+000 I				9.6E-003 C	8.9E-004 C	4.5E-004 C	8.2E-001 C	9.1E-002 C	2.4E-006	4.7E-005 C
N-NITROSO-N-ETHYLUREA	759739		1.40E+002 H				4.8E-004 C	4.5E-005 C	2.3E-005 C	4.1E-002 C	4.6E-003 C		
N-NITROSO-N-METHYLETHYLAMINE	10595956		2.20E+001 I				3.0E-003 C	2.8E-004 C	1.4E-004 C	2.6E-001 C	2.9E-002 C		
N-NITROSOPYRROLIDINE	930552		2.10E+000 I		2.10E+000 I		3.2E-002 C	3.0E-003 C	1.5E-003 C	2.7E+000 C	3.0E-001 C		
M-NITROTOLUENE	99081	2.00E-002 E				y	1.2E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N		
O-NITROTOLUENE	88722	1.00E-002 H				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
P-NITROTOLUENE	99990	1.00E-002 H				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
NUSTAR	85509199	7.00E-004 I					2.6E+001 N	2.6E+000 N	9.5E-001 N	1.4E+003 N	5.5E+001 N		
ORYZALIN	19044883	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
OXADIAZON	19666309	5.00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
OXAMYL	23135220	2.50E-002 I					9.1E+002 N	9.1E+001 N	3.4E+001 N	5.1E+004 N	2.0E+003 N	1.9E-001	3.8E+000 N
OXYFLUORFEN	42874033	3.00E-003 I					1.1E+002 N	1.1E+001 N	4.1E+000 N	6.1E+003 N	2.3E+002 N		

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Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Risk-based concentrations: Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil: Industrial mg/kg	Residential mg/kg	Region III SSLs, Soil, for groundwater migration: DAF 1 mg/kg	DAF 20 mg/kg
PARAQUAT DICHLORIDE	1910425	4.50E-003 I					1.6E+002 N	1.6E+001 N	6.1E+000 N	9.2E+003 N	3.5E+002 N		
PARATHION	56382	6.00E-003 H					2.2E+002 N	2.2E+001 N	8.1E+000 N	1.2E+004 N	4.7E+002 N	5.0E-001	1.0E+001 N
PENTACHLOROBENZENE	608935	8.00E-004 I					2.9E+001 N	2.9E+000 N	1.1E+000 N	1.6E+003 N	6.3E+001 N	1.0E+000	2.0E+001 N
PENTACHLORONITROBENZENE	82688	3.00E-003 I	2.60E-001 H				2.6E-001 C	2.4E-002 C	1.2E-002 C	2.2E+001 C	2.5E+000 C	4.1E-003	8.2E-002 C
PENTACHLOROPHENOL	87865	3.00E-002 I	1.20E-001 I				5.6E-001 C	5.2E-002 C	2.6E-002 C	4.8E+001 C	5.3E+000 C		
PERMETHRIN	52645531	5.00E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N	1.2E+002	2.4E+003 N
PHENOL	108952	6.00E-001 I					2.2E+004 N	2.2E+003 N	8.1E+002 N	1.2E+006 N	4.7E+004 N	6.7E+000	1.3E+002 N
M-PHENYLENEDIAMINE	108452	6.00E-003 I					2.2E+002 N	2.2E+001 N	8.1E+000 N	1.2E+004 N	4.7E+002 N	4.9E-002	9.8E-001 N
O-PHENYLENEDIAMINE	95545		4.70E-002 H				1.4E+000 C	1.3E-001 C	6.7E-002 C	1.2E+002 C	1.4E+001 C		
P-PHENYLENEDIAMINE	106503	1.90E-001 H					6.9E+003 N	6.9E+002 N	2.6E+002 N	3.9E+005 N	1.5E+004 N		
2-PHENYLPHENOL	90437		1.90E-003 H				3.5E+001 C	3.3E+000 C	1.7E+000 C	3.0E+003 C	3.4E+002 C		
PHOSPHINE	7803512	3.00E-004 I		8.60E-005 I			1.1E+001 N	3.1E-001 N	4.1E-001 N	6.1E+002 N	2.3E+001 N		
PHOSPHORIC ACID	7664382			2.90E-003 I				1.1E+001 N					
PHOSPHORUS (WHITE)	7723140	2.00E-005 I					7.3E-001 N	7.3E-002 N	2.7E-002 N	4.1E+001 N	1.6E+000 N		
P-PHTHALIC ACID	100210	1.00E+000 H					3.7E+004 N	3.7E+003 N	1.4E+003 N	2.0E+006 N	7.8E+004 N		
PHTHALIC ANHYDRIDE	85449	2.00E+000 I		3.43E-002 H			7.3E+004 N	1.3E+002 N	2.7E+003 N	4.1E+006 N	1.6E+005 N	2.6E+001	5.2E+002 N
POLYBROMINATED BIPHENYLS		7.00E-006 H	8.90E+000 H				7.5E-003 C	7.0E-004 C	3.5E-004 C	6.4E-001 C	7.2E-002 C !		
POLYCHLORINATED BIPHENYLS	1336363		2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C	2.1E-002	[illegible]
AROCLOR-1016	12674112	7.00E-005 I	7.00E-002 I		7.00E-002 I		9.6E-001 C !	8.9E-002 C !	4.5E-002 C !	8.2E+001 C !	5.5E+000 N	2.1E-001	[illegible]
AROCLOR-1221	11104282		2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C		
AROCLOR-1232	11141165		2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C		
AROCLOR-1242	53469219		2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C		
AROCLOR-1248	12672296		2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C		
AROCLOR-1254	11097691	2.00E-005 I	2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C !	5.4E-002	1.1E+000
AROCLOR-1260	11096825		2.00E+000 I		2.00E+000 I		3.3E-002 C	3.1E-003 C	1.6E-003 C	2.9E+000 C	3.2E-001 C		
POLYCHLORINATED TERPHENYLS	61788338		4.50E+000 E				1.5E-002 C	1.4E-003 C	7.0E-004 C	1.3E+000 C	1.4E-001 C		
POLYNUCLEAR AROMATIC HYDROCARBONS:													
ACENAPHTHENE	83329	6.00E-002 I				y	3.7E+002 N	2.2E+002 N	8.1E+001 N	1.2E+005 N	4.7E+003 N	5.2E+000	1.0E+002 N
ANTHRACENE	120127	3.00E-001 I				y	1.8E+003 N	1.1E+003 N	4.1E+002 N	6.1E+005 N	2.3E+004 N	2.3E+001	[illegible]
BENZ[A]ANTHRACENE	56553		7.30E-001 E				9.2E-002 C	8.6E-003 C	4.3E-003 C	7.8E+000 C	8.7E-001 C	7.3E-002	[illegible]
BENZO[B]FLUORANTHENE	205992		7.30E-001 E				9.2E-002 C	8.6E-003 C	4.3E-003 C	7.8E+000 C	8.7E-001 C	2.3E-001	4.5E+000 C
BENZO[K]FLUORANTHENE	207089		7.30E-002 E				9.2E-001 C	8.6E-002 C	4.3E-002 C	7.8E+001 C	8.7E+000 C	2.3E+000	4.5E+001 C
BENZO[A]PYRENE	50328		7.30E+000 I		3.10E+000 E		9.2E-003 C	2.0E-003 C	4.3E-004 C	7.8E-001 C	8.7E-002 C	1.9E-002	3.7E-001 C
CARBAZOLE	86748		2.00E-002 H				3.3E+000 C	3.1E-001 C	1.6E-001 C	2.9E+002 C	3.2E+001 C	2.3E-002	4.7E-001 C
CHRYSENE	218019		7.30E-003 E				9.2E+000 C	8.6E-001 C	4.3E-001 C	7.8E+002 C	8.7E+001 C	7.3E+000	1.5E+002 C
DIBENZ[A,H]ANTHRACENE	53703		7.30E+000 E				9.2E-003 C	8.6E-004 C	4.3E-004 C	7.8E-001 C	8.7E-002 C	7.0E-002	1.4E+000 C
DIBENZOFURAN	132649	4.00E-003 E				y	2.4E+001 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N	3.8E-001	7.7E+000 N
FLUORANTHENE	206440	4.00E-002 I					1.5E+003 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N	3.1E+002	6.3E+003 N
FLUORENE	86737	4.00E-002 I				y	2.4E+002 N	1.5E+002 N	5.4E+001 N	8.2E+004 N	3.1E+003 N	6.8E+000	1.4E+002 N
INDENO[1,2,3-C,D]PYRENE	193395		7.30E-001 E				9.2E-002 C	8.6E-003 C	4.3E-003 C	7.8E+000 C	8.7E-001 C	6.4E-001	1.3E+001 C
2-METHYLNAPHTHALENE	91576	2.00E-002 E				y	1.2E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	1.1E+000	2.2E+001 N
NAPHTHALENE	91203	2.00E-002 I		9.00E-004 I		y	6.5E+000 N	3.3E+000 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	7.7E-003	1.5E-001 N
PYRENE	129000	3.00E-002 I				y	1.8E+002 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N	3.4E+001	6.8E+002 N
PROMETON	1610180	1.50E-002 I					5.5E+002 N	5.5E+001 N	2.0E+001 N	3.1E+004 N	1.2E+003 N		
PROMETRYN	7287196	4.00E-003 I					1.5E+002 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N		

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Basis: C = Carcinogenic effects N = Noncarcinogenic effects 1 = RBC at HI of 0.1 < RBC-c

							Risk-based concentrations					Region III SSLs Soil, for groundwater migration	
Chemical	CAS	RfDo mg/kg/d	CSFo 1/mg/kg/d	RfDi mg/kg/d	CSFi 1/mg/kg/d	VOC	Tap water ug/l	Ambient air ug/m3	Fish mg/kg	Soil Industrial mg/kg	Residential mg/kg	DAF 1 mg/kg	DAF 20 mg/kg
PROPACHLOR	1918167	1.30E-002 I					4.7E+002 N	4.7E+001 N	1.8E+001 N	2.7E+004 N	1.0E+003 N		
PROPANIL	709988	5.00E-003 I					1 8E+002 N	1 8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
PROPARGITE	2312358	2.00E-002 I					7 3E+002 N	7.3E+001 N	2 7E+001 N	4 1E+004 N	1.6E+003 N		
N-PROPYLBENZENE		1.00E-002 E				y	6.1E+001 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N	3 6E-001	[illegible]
PROPYLENE GLYCOL	57556	2 00E+001 H					7.3E+005 N	7.3E+004 N	2.7E+004 N	4.1E+007 N	1.6E+006 N		
PROPYLENE GLYCOL, MONOETHYL ETHER	52125538	7 00E-001 H					2.6E+004 N	2.6E+003 N	9.5E+002 N	1.4E+006 N	5 5E+004 N		
PROPYLENE GLYCOL, MONOMETHYL ETHER	107982	7 00E-001 H		5 70E-001 I			2.6E+004 N	2.1E+003 N	9.5E+002 N	1.4E+006 N	5.5E+004 N		
PURSUIT	81335775	2.50E-001 I					9.1E+003 N	9.1E+002 N	3.4E+002 N	5.1E+005 N	2.0E+004 N		
PYRIDINE	110861	1.00E-003 I					3.7E+001 N	3.7E+000 N	1.4E+000 N	2.0E+003 N	7.8E+001 N		
QUINOLINE	91225		1.20E+001 H				5.6E-003 C	5.2E-004 C	2.6E-004 C	4.8E-001 C	5.3E-002 C		
RDX	121824	3.00E-003 I	1.10E-001 I				6.1E-001 C	5.7E-002 C	2 9E-002 C	5.2E+001 C	5.8E+000 C		
RESMETHRIN	10453868	3.00E-002 I					1.1E+003 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N		
RONNEL	299843	5.00E-002 H					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
ROTENONE	83794	4.00E-003 I					1.5E+002 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N		
SELENIOUS ACID	7783008	5 00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
SELENIUM	7782492	5 00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N	9 5E-001	[illegible]
SILVER	7440224	5.00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N	1 6E+000	[illegible]
SIMAZINE	122349	5.00E-003 I	1.20E-001 H				5.6E-001 C	5 2E-002 C	2.6E-002 C	4.8E+001 C	5.3E+000 C	1 7E-004	[illegible]
SODIUM AZIDE	26628228	4 00E-003 I					1.5E+002 N	1.5E+001 N	5.4E+000 N	8.2E+003 N	3.1E+002 N		
SODIUM DIETHYLDITHIOCARBAMATE	148185	3.00E-002 I	2.70E-001 H				2.5E-001 C	2.3E-002 C	1.2E-002 C	2.1E+001 C	2.4E+000 C		
STRONTIUM, STABLE	7440246	6.00E-001 I					2.2E+004 N	2.2E+003 N	8.1E+002 N	1.2E+006 N	4.7E+004 N	7.7E+002	[illegible]
STRYCHNINE	57249	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N	8 3E-003	[illegible]
STYRENE	100425	2.00E-001 I		2.86E-001 I		y	1.6E+003 N	1.0E+003 N	2.7E+002 N	4.1E+005 N	1.6E+004 N	2.9E+000	[illegible]
2,3,7,8-TETRACHLORODIBENZODIOXIN	1746016		1.50E+005 H		1.50E+005 H		4.5E-007 C	4.2E-008 C	2.1E-008 C	3.8E-005 C	4.3E-006 C	4.3E-007	[illegible]
1,2,4,5-TETRACHLOROBENZENE	95943	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N	3.3E-002	[illegible]
1,1,1,2-TETRACHLOROETHANE	630206	3.00E-002 I	2.60E-002 I		2.60E-002 I	y	4.1E-001 C	2.4E-001 C	1.2E-001 C	2.2E+002 C	2.5E+001 C	2 0E-004	[illegible]
1,1,2,2-TETRACHLOROETHANE	79345	6.00E-002 E	2.00E-001 I		2.00E-001 I	y	5 3E-002 C	3.1E-002 C	1.6E-002 C	2.9E+001 C	3.2E+000 C	3 4E-005	[illegible]
TETRACHLOROETHENE	127184	1.00E-002 I	5.20E-002 E	1.4E-001 E	2 00E-003 E	y	1.1E+000 C	3.1E+000 C	6.1E-002 C	1.1E+002 C	1.2E+001 C	2 4E-003	[illegible]
2,3,4,6-TETRACHLOROPHENOL	58902	3.00E-002 I					1.1E+003 N	1.1E+002 N	4 1E+001 N	6.1E+004 N	2 3E+003 N		
P,A,A,A-TETRACHLOROTOLUENE	5216251		2.00E+001 H				3.3E-003 C	3.1E-004 C	1.6E-004 C	2 9E-001 C	3.2E-002 C		
1,1,1,2-TETRAFLUOROETHANE	811972			2 29E+001 I		y	1 7E+005 N	8.4E+004 N					
**TETRAHYDROFURAN	109999	2.00E-001 E	7.6E-003 E	8.6E-002 E	6.8E-003 E		8.8E+000 C	9.2E-001 C	4 2E-001 C	7.5E+002 C	8.4E+001 C		
TETRYL	479458	1.00E-002 H					3 7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
THALLIC OXIDE	1314325	7.00E-005 W					2.6E+000 N	2.6E-001 N	9.5E-002 N	1.4E+002 N	5 5E+000 N		
THALLIUM	7440280	7.00E-005 O					2.6E+000 N	2.6E-001 N	9.5E-002 N	1.4E+002 N	5.5E+000 N	1 8E-001	[illegible]
THALLIUM ACETATE	563688	9.00E-005 I					3.3E+000 N	3 3E-001 N	1.2E-001 N	1.8E+002 N	7.0E+000 N		
THALLIUM CARBONATE	6533739	8.00E-005 I					2.9E+000 N	2.9E-001 N	1.1E-001 N	1.6E+002 N	6.3E+000 N		
THALLIUM CHLORIDE	7791120	8.00E-005 I					2.9E+000 N	2.9E-001 N	1.1E-001 N	1.6E+002 N	6.3E+000 N		
THALLIUM NITRATE	10102451	9.00E-005 I					3.3E+000 N	3.3E-001 N	1.2E-001 N	1.8E+002 N	7 0E+000 N		
THALLIUM SULFATE (2:1)	7446180	8.00E-005 I					2.9E+000 N	2.9E-001 N	1.1E-001 N	1.6E+002 N	6.3E+000 N		
THIOBENCARB	28249776	1 00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N		
TIN	7440315	6.00E-001 H					2.2E+004 N	2.2E+003 N	8.1E+002 N	1.2E+006 N	4.7E+004 N		

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Basis: C = Carcinogenic effects N = Noncarcinogenic effects ! = RBC at HI of 0.1 < RBC-c

							Risk-based concentrations					Region III SSLs	
												Soil, for groundwater migration	
		RfDo	CSFo	RfDi	CSFi		Tap water	Ambient air	Fish	Soil Industrial	Residential	DAF 1	DAF 20
Chemical	CAS	mg/kg/d	1/mg/kg/d	mg/kg/d	1/mg/kg/d	VOC	ug/l	ug/m3	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
TITANIUM	7440326	4.00E+000 E		8.60E-003 E			1.5E+005 N	3.1E+001 N	5.4E+003 N	8.2E+006 N	3.1E+005 N		
TITANIUM DIOXIDE	13463677	4.00E+000 E		8.60E-003 E			1.5E+005 N	3.1E+001 N	5.4E+003 N	8.2E+006 N	3.1E+005 N		
TOLUENE	108883	2.00E-001 I		1.14E-001 I		y	7.5E+002 N	4.2E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N	4.4E-001	[illegible]
TOLUENE-2,4-DIAMINE	95807		3.20E+000 H				2.1E-002 C	2.0E-003 C	9.9E-004 C	1.8E+000 C	2.0E-001 C		
TOLUENE-2,5-DIAMINE	95705	6.00E-001 H					2.2E+004 N	2.2E+003 N	8.1E+002 N	1.2E+006 N	4.7E+004 N		
TOLUENE-2,6-DIAMINE	823405	2.00E-001 H					7.3E+003 N	7.3E+002 N	2.7E+002 N	4.1E+005 N	1.6E+004 N		
P-TOLUIDINE	106490		1.90E-001 H				3.5E-001 C	3.3E-002 C	1.7E-002 C	3.0E+001 C	3.4E+000 C	3.0E-004	[illegible]
TOXAPHENE	8001352		1.10E+000 I		1.10E+000 I		6.1E-002 C	5.7E-003 C	2.9E-003 C	5.2E+000 C	5.8E-001 C	3.1E-002	[illegible]
1,2,4-TRIBROMOBENZENE	615543	5.00E-003 I					1.8E+002 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N		
TRIBUTYLTIN OXIDE	56359	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N		
2,4,6-TRICHLOROANILINE	634935		3.40E-002 H				2.0E+000 C	1.8E-001 C	9.3E-002 C	1.7E+002 C	1.9E+001 C		
1,2,4-TRICHLOROBENZENE	120821	1.00E-002 I		5.70E-002 H		y	1.9E+002 N	2.1E+002 N	1.4E+001 N	2.0E+004 N	7.8E+002 N	3.8E-001	[illegible]
1,1,1-TRICHLOROETHANE	71556	2.00E-002 E		2.86E-001 E		y	5.4E+002 N	1.0E+003 N	2.7E+001 N	4.1E+004 N	1.6E+003 N	5.1E-001	[illegible]
1,1,2-TRICHLOROETHANE	79005	4.00E-003 I	5.70E-002 I		5.60E-002 I	y	1.9E-001 C	1.1E-001 C	5.5E-002 C	1.0E+002 C	1.1E+001 C	3.9E-005	[illegible]
TRICHLOROETHENE	79016	6.00E-003 E	1.10E-002 E		6.00E-003 E	y	1.6E+000 C	1.0E+000 C	2.9E-001 C	5.2E+002 C	5.8E+001 C !	7.7E-004	[illegible]
TRICHLOROFLUOROMETHANE	75694	3.00E-001 I		2.00E-001 A		y	1.3E+003 N	7.3E+002 N	4.1E+002 N	6.1E+005 N	2.3E+004 N	1.1E+000	[illegible]
2,4,5-TRICHLOROPHENOL	95954	1.00E-001 I					3.7E+003 N	3.7E+002 N	1.4E+002 N	2.0E+005 N	7.8E+003 N		
2,4,6-TRICHLOROPHENOL	88062		1.10E-002 I		1.00E-002 I		6.1E+000 C	6.3E-001 C	2.9E-001 C	5.2E+002 C	5.8E+001 C		
2,4,5-T	93765	1.00E-002 I					3.7E+002 N	3.7E+001 N	1.4E+001 N	2.0E+004 N	7.8E+002 N	9.8E-002	[illegible]
2-(2,4,5-TRICHLOROPHENOXY)PROPIONIC ACID	93721	8.00E-003 I					2.9E+002 N	2.9E+001 N	1.1E+001 N	1.6E+004 N	6.3E+002 N	1.1E+000	[illegible]
1,1,2-TRICHLOROPROPANE	598776	5.00E-003 I				y	3.0E+001 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N	1.2E-002	[illegible]
1,2,3-TRICHLOROPROPANE	96184	6.00E-003 I	7.00E+000 H			y	1.5E-003 C	8.9E-004 C	4.5E-004 C	8.2E-001 C	9.1E-002 C	5.2E-007	[illegible]
1,2,3-TRICHLOROPROPENE	96195	5.00E-003 H				y	3.0E+001 N	1.8E+001 N	6.8E+000 N	1.0E+004 N	3.9E+002 N	1.2E-002	[illegible]
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	76131	3.00E+001 I		8.60E+000 H		y	5.9E+004 N	3.1E+004 N	4.1E+004 N	6.1E+007 N	2.3E+006 N	1.2E+002	[illegible]
1,2,4-TRIMETHYLBENZENE	95636	5.00E-002 E		1.70E-003 E		y	1.2E+001 N	6.2E+000 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
1,3,5-TRIMETHYLBENZENE	108678	5.00E-002 E		1.70E-003 E		y	1.2E+001 N	6.2E+000 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		
TRIMETHYL PHOSPHATE	512561		3.70E-002 H				1.8E+000 C	1.7E-001 C	8.5E-002 C	1.5E+002 C	1.7E+001 C		
1,3,5-TRINITROBENZENE	99354	3.00E-002 I					1.1E+003 N	1.1E+002 N	4.1E+001 N	6.1E+004 N	2.3E+003 N		
2,4,6-TRINITROTOLUENE	118967	5.00E-004 I	3.00E-002 I				2.2E+000 C !	2.1E-001 C !	1.1E-001 C !	1.9E+002 C !	2.1E+001 C !		
URANIUM (SOLUBLE SALTS)		3.00E-003 I					1.1E+002 N	1.1E+001 N	4.1E+000 N	6.1E+003 N	2.3E+002 N		
VANADIUM	7440622	7.00E-003 H					2.6E+002 N	2.6E+001 N	9.5E+000 N	1.4E+004 N	5.5E+002 N	2.6E+002	[illegible]
VANADIUM PENTOXIDE	1314621	9.00E-003 I					3.3E+002 N	3.3E+001 N	1.2E+001 N	1.8E+004 N	7.0E+002 N		
VANADIUM SULFATE	16785812	2.00E-002 H					7.3E+002 N	7.3E+001 N	2.7E+001 N	4.1E+004 N	1.6E+003 N		
VINCLOZOLIN	50471448	2.50E-002 I					9.1E+002 N	9.1E+001 N	3.4E+001 N	5.1E+004 N	2.0E+003 N		
VINYL ACETATE	108054	1.00E+000 H		5.71E-002 I		y	4.1E+002 N	2.1E+002 N	1.4E+003 N	2.0E+006 N	7.8E+004 N	8.7E-002	[illegible]
VINYL CHLORIDE	75014		1.90E+000 H		3.00E-001 H	y	1.9E-002 C	2.1E-002 C	1.7E-003 C	3.0E+000 C	3.4E-001 C	7.9E-006	[illegible]
WARFARIN	81812	3.00E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N	2.2E-002	[illegible]
M-XYLENE	108383	2.00E+000 H				y	1.2E+004 N	7.3E+003 N	2.7E+003 N	4.1E+006 N	1.6E+005 N	1.3E+001	[illegible]
O-XYLENE	95476	2.00E+000 H				y	1.2E+004 N	7.3E+003 N	2.7E+003 N	4.1E+006 N	1.6E+005 N	1.1E+001	[illegible]
P-XYLENE	106423					y							
XYLENES	1330207	2.00E+000 I				y	1.2E+004 N	7.3E+003 N	2.7E+003 N	4.1E+006 N	1.6E+005 N	8.5E+000	[illegible]
ZINC	7440666	3.00E-001 I					1.1E+004 N	1.1E+003 N	4.1E+002 N	6.1E+005 N	2.3E+004 N	6.8E+002	[illegible]
ZINC PHOSPHIDE	1314847	3E-004 I					1.1E+001 N	1.1E+000 N	4.1E-001 N	6.1E+002 N	2.3E+001 N		
ZINEB	12122677	5E-002 I					1.8E+003 N	1.8E+002 N	6.8E+001 N	1.0E+005 N	3.9E+003 N		

D. Mean concentrations of organic parameters, arsenic and metals, and organochlorine compounds in stream sediments at background sites were computed and contrasted with constituent means for all sampling locations (Table 6 , page 24).

9. STREAM SEDIMENT CLASSIFICATION: Based on standard deviations from background means, a five tier Classification of Illinois Stream Sediments was developed for constituents for which adequate data was available.

CLASSIFICATION OF ILLINOIS STREAM SEDIMENTS

NUTRIENTS AND HEAVY METALS: Ranges of concentrations displayed and resultant groupings are based on one, two, four and eight standard deviations from background mean. Unless otherwise noted concentrations are in mg/kg sediment dry weight.

PARAMETER	NON-ELEVATED	SLIGHTLY ELEVATED	ELEVATED	HIGHLY ELEVATED	EXTREME
COD	<90000	>90000	>132000	>215000	>380000
Total Kjeldahl Nitrogen	<2300	>2300	>3200	>5100	>8800
Total Volatile Solids (%)	<6.5	>6.5	>8.8	>13	>22
Total Phosphorus	<80	>80	>1100	>1700	>3000
Arsenic	<8.0	>8.0	>11	>17	>28
Chromium	<16	>16	>23	>38	>60
Copper	<38	>38	>60	>100	>200
Iron	<18000	>18000	>23000	>32000	>50000
Lead	<28	>28	>38	>60	>100
Manganese	<1300	>1300	>1800	>2800	>5000
Mercury	<0.07	>0.07	>0.10	>0.17	>0.30
Zinc	<80	>80	>100	>170	>300

CADMIUM AND ORGANOCHLORINE COMPOUNDS: Ranges of concentrations and resultant groupings are based on 50, 65, 80 and 95 percent distributions for all samples. Cadmium concentrations are in mg/kg and organochlorine concentrations are in µg/kg sediment dry weight.

PARAMETER	NON-ELEVATED	SLIGHTLY ELEVATED	ELEVATED	HIGHLY ELEVATED	EXTREME
Cadmium	<0.5	>0.5	>1.0	>2.0	>20.0
Chlordane	<5	>5	>6	>10	>40
Sum DDT	<6.0	>6.0	>10	>35	>200
Dieldrin	<3.5	>3.5	>6	>10	>25
Heptachlor Epoxide	<1.0	>1.0	>1.5	>3	>9
PCBs	<10	>20	>50	>200	>1500

N-Nitrosodiphenylamine

Section 742.APPENDIX A: General

Section 742.TABLE G: Concentrations of Inorganic Chemicals in Background Soils

Chemical Name	Counties Within Metropolitan Statistical Areas[a] (mg/kg)	Counties Outside Metropolitan Statistical Areas (mg/kg)
Aluminum	9,500	9,200
Antimony	4.0	3.3
Arsenic	7.2	5.2
Barium	110	122
Beryllium	0.59	0.56
Cadmium	0.6	0.50
Calcium	9,300	5,525
Chromium	16.2	13.0
Cobalt	8.9	8.9
Copper	19.6	12.0
Cyanide	0.51	0.50
Iron	15,900	15,000
Lead	36.0	20.9
Magnesium	4,820	2,700
Manganese	636	630
Mercury	0.06	0.05

[a]Counties within Metropolitan Statistical Areas: Boone, Champaign, Clinton, Cook, DuPage, Grundy, Henry, Jersey, Kane, Kankakee, Kendall, Lake, Macon, Madison, McHenry, McLean, Menard, Monroe, Peoria, Rock Island, Sangamon, St. Clair, Tazewell, Will, Winnebago and Woodford.

7.0 WSW Problem Formulation

7.1 Site Characterization

7.1.1 Site History

The former Wisconsin Steel Works site began production of steel in the year 1875 under the name of Brown Iron and Steel Works/Brown Mill. It is located along the Calumet River, between East 100th and 114th street. The site is divided by 106th street and is composed of 176 acres built on dredged material.

There are two vessel slips located south of 106th street. The northern most slip is known as the North (Wisconsin) Slip while the southern most slip is known as the South (Semet-Solvay) Vessel Slip. Both slips lead from the main steel plant area into the Calumet River. The North Vessel Slip is approximately 374 meters long and 55 meters wide. It is bordered to the North by the Ore Yard, to the South by the Coke Plant and to the West by the Steel Production area. The South Vessel Slip is approximately 294 meters long and 53 meters wide. It is bordered to the North by the Coal Storage area and to the West by the Steel Production area (see Figure 7-1).

Operations started in 1875 and by 1930, the facility had developed into an integrated steel manufacturing plant. Operations included a coke battery (for the conversion of coal into coke), blast furnace (processing iron ore into iron), basic oxygen and open hearth furnaces (refining iron into steel) and steel casting and milling. The plant was in continuous production of coke, pig iron and steel until 1980. The site has undergone several ownerships. In 1977, International Harvester Company (now known as Navistar International) sold the site to EDC Holding Company, a subsidiary of Envirodyne Industries. When EDC declared bankruptcy in 1980, the Economic Development Administration of the US Department of Commerce (EDA) acquired primary ownership of the site (90%) while Navistar acquired the remaining 10%. In 1982, the steel mill facility was shut down and assets began to be sold.

In 1991, the US EDA entered into a memorandum of agreement with the USACE to undertake the environmental remediation of the site. From May 1991 to July 1992, the Corps of Engineers performed the environmental remediation at the site. The USACE found arsenic, cyanide, heavy metals, PAHs and PCBs as the contaminants in the soil and groundwater of the site. In 1999, Navistar acquired the property from the EDA and voluntarily assumed responsibility for completing the environmental investigation and site remediation. Geraghty & Miller was contracted by Navistar to carry out the site environmental investigations.

7.1.2 Previous Investigations

In 1991, the US EDA and US Army Corps of Engineers agreed to proceed with the environmental remediation of the site. Remediation activities occurred from May 1991 through July 1992. These activities included removal and disposal of hazardous liquids and sludges, stabilization of soils to reduce leaching and cutting and removal of mooring posts to discourage docking by the site. The ACOE found arsenic, cyanide, heavy metals, PAHs and PCBs as the contaminants in the soil and ground water of the site. The site was not completely remediated as it still contained "hot spots" or areas of contaminated soil.

After Navistar regained ownership of the site, responsibility for site environmental investigation and remediation was transferred to Geraghty & Miller Co. as the representative for Navistar. In 1998, a draft preliminary risk assessment of the WSW site was submitted to the IEPA and community for comments (Navistar, 1998). The draft contained detail of the site activities and procedures to be followed during a Phase II site investigation. Navistar issued a response to comments received on its draft preliminary risk assessment. As part of the comments, it was suggested that Navistar characterize contaminant hot spots in the North and South Vessel Slip sediments. Navistar responded that the quality of the sediments in the North and South Vessel Slips did not affect future industrial/commercial redevelopment activities and that as such, no work would be carried out at the vessel slips.

In December 1999, Geraghty & Miller published an Ecological Risk Assessment evaluating the potential for adverse effects in the vessel slips as a result of sediment-derived chemicals. The report concluded that no "imminent hazard to the aquatic community" existed and therefore, there were no recommendations for remmediation of the vessel slips (Geraghty & Miller, 1999).

There have been several independent ecological studies carried out on the state of the Calumet River and the WSW vessel slips. The USFWS carried out an Ecological Impact Assessment, published in 1994. The USFWS concluded that the sediments in both vessel slips contained elevated concentrations of heavy metals. Results of toxicity tests using larval fathead minnows demonstrated that contaminants released from the sediments collected in the west section of the South Vessel Slip are acutely toxic to fish (USFWS, 1994). In addition, the macroinvertebrate community in the vessel slips was scarce when compared to reference conditions. The USFWS concluded that the sediments in the vessel slips be remediated as they had a potential to cause adverse effects on the environment of the river.

The IEPA also conducted an ecological study of the WSW vessel slips. Sediment and surface water samples were taken from the vessel slips in June of 1996. For the purpose of this report, both the USFWS and IEPA data was used for analysis of contamination.

7.2 Data Summary

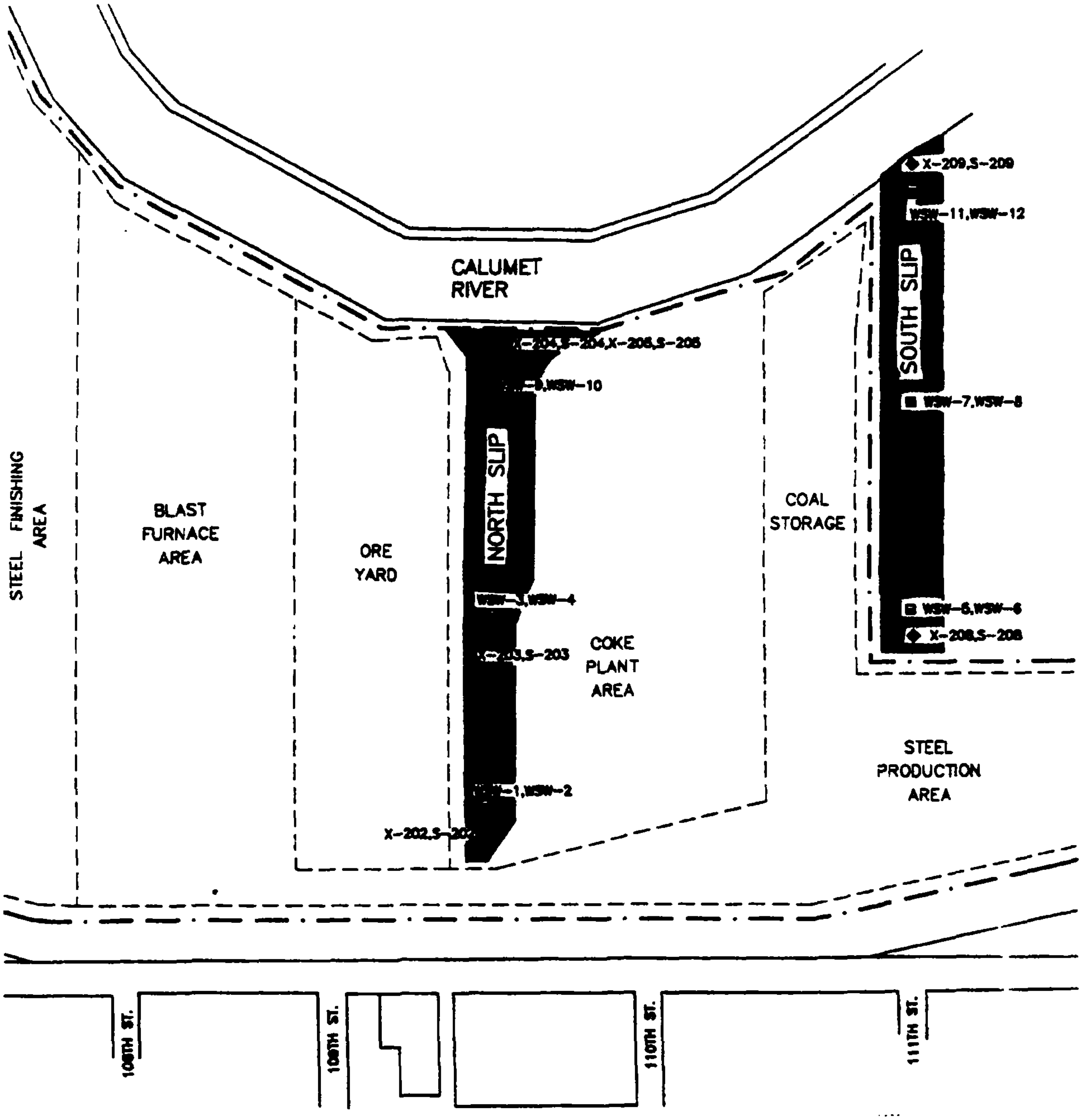
This section contains the results of the ecological study carried out by the USFWS and IEPA. Results are broken down into the following categories:

- Measurements of Sediment Chemistry
- Measurements of Surface Water Chemistry
- Toxicity Testing
- Tissue Residue Analyses
- Macroinvertebrate Community Structure

7.2.1 Sediments

Sediments were collected by the USFWS in July of 1993, using a nine-inch ponar dredge (USFWS, 1994). The vessel slips were subdivided into three sampling sections. The sampling sites were arbitrarily chosen to be located at the far western end of the vessel slips, middle, and confluence with the Calumet River (or East End). Two sampling stations (no more than six feet apart) were placed within each section of the slips. A total of twelve sampling stations were placed in the North and South Slips (six in each vessel slip). The location of the sampling stations is shown on Figure 7-1. The sediments were analyzed for PAHs, metals, PCBs, VOCs, and TRPHs. Sediment samples were also taken along the seawall (bank adjacent to the WSW site) in the Calumet River. The USFWS chose to position these downstream of outfall structures originating from the WSW site. However, these sediment samples were not submitted for chemical analysis due to incomplete sediment grabs.

Sediment chemistry data for all twelve sampling stations is shown in Appendix D. The data was analyzed by taking the average chemical concentrations for sampling stations located within the same section. This calculated value was used as the representative chemical concentration for the given section of the vessel slip. This was done in order to determine the overall sediment quality of each section of the vessel slips. A sample calculation of chemistry data is presented in Table 7-1. Sampling stations 1 and 2 were positioned at the west section of the North Vessel Slip. The measured calculations of two PAHs are shown in the table. The measured concentrations, moisture content and TOC values were averaged and taken



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SCALE IN FEET

■ USFWS Sediment Sampling Stations:
WSW-1 & WSW-2: West End North Vessel Slip
WSW-3 & WSW-4: Middle Section North Vessel Slip
WSW-9 & WSW-10: East End North Vessel Slip

WSW-5 & WSW-6: West End South Vessel Slip
WSW-7 & WSW-8: Middle Section South Vessel Slip
WSW-11 & WSW-12: East End South Vessel Slip

◆ IEPA Sediment Sampling Stations:
X-Sediment Sample
S-Surface Water Sample

Source: Geraghty & Miller, 1999

FIGURE 1:
SEDIMENT AND SURFACE
WATER SAMPLE LOCATIONS
WISCONSIN STEEL WORKS
SITE

as the representative values for the west section of the North Vessel Slip. The averaged concentration of naphthalene was therefore 945 ppb. This concentration was determined to be the representative concentration of naphthalene at the West End of the North Vessel Slip.

Table 7-1
Example calculation of chemistry data

USFWS North Slip - West Section (ppb)			
	WSW-1A+B	WSW-2A+B	Average
Moisture Content (%)	60	60	60
TOC	0.0381	0.0353	0.0367
PAHs			
Naphthalene	890	1000	945
Acenapthylene	330	370	350

The IEPA also collected sediment samples from the North and South Vessel Slips in June of 1996. The measured sediment chemistry data for all IEPA sampling stations is shown in Appendix D. Sampling consisted of four sediment and surface water samples from the North Slip and two sediment and surface water samples from the South Slip. The sampling stations of the North Vessel Slip were arbitrarily positioned on the far western end of the slip, middle section and confluence of the Calumet River with the vessel slip (or East End). Two sampling stations were set up in the South Slip at the far western and eastern end of the vessel slip. No samples were taken from the middle section of the South Vessel Slip. Locations of IEPA sampling stations are shown in Figure 7-1.

For the purposes of this report, both the USFWS data and IEPA data was used for analysis of contamination. Averaged chemical concentrations from the USFWS study were compared to measured concentrations from the IEPA investigation (see Appendix D). The highest value was chosen as the representative chemical concentration for that section of the vessel slip. This was done in order to produce conservative estimates of risk that best guarantee the protection of human health and ecology of the vessel slips and the Calumet River.

Data summaries presented as wet and dry weight are shown in Appendix D. The data is presented on a sampling station and section basis, dividing each vessel slip into the West End, middle section and East End.

The chemical data reported by the USFWS as dry weight were determined to be wet weight chemical concentrations (Geraghty & Miller, 1999). As a result, the wet weight chemical data was converted to dry weight concentrations. For a detailed description of the methodology, please refer to Appendix D.

7.2.2 Surface Water

In June 1996, the IEPA collected four surface water samples from the North and two surface water samples from the South Vessel Slips. Four sampling stations were arbitrarily positioned on the far western end of the North Slip, the middle section of the North Slip and on the confluence of the North Vessel Slip with the Calumet River (or Eastern End). A total of two sampling stations were positioned on the far western end of the South Slip and on the confluence of the South Vessel Slip with the Calumet River (or Eastern End of the South Slip). The locations of the sampling stations are shown on Figure 7-1.

The IEPA collected surface water samples using a "Bacon Bomber" sampler (Geraghty & Miller, 1999). The water samples were taken from a depth of approximately 4 to 6 feet below the river surface. The samples were analyzed for metals, VOCs, semi-VOCs, pesticides, and PCBs. The raw surface water data is presented in Appendix E. There is no chemical data on surface water PAHs.

7.2.3 Toxicity Tests

Sediments collected from sampling stations 1,2,3,5,6,7,9, and 11 were used to perform and fish toxicity tests. Larval Fathead minnows (*Pimephales promelas*) were chosen as the indicator organism in the fish toxicity tests. The fish toxicity tests consisted of duplicate, 96-hour acute bioassays. The USFWS monitored the pH, dissolved oxygen, and ammonia concentrations during the experiment. These toxicity tests were used to assess the response of organisms to the chemicals found in the sediments of the vessel slips. Results of the toxicity tests are shown in Table 7-2.

Table 7-2
Results of fish toxicity tests (USFWS, 1994)

Station Number and Replicate	% Mortality at 96 Hours	
	Control	Sample
FIRST ROUND OF SAMPLING (July, 1993)		
North Barge Slip:		
1a	5	0
1b	15	3
3a	5	10
3b	15	0
9a	10	5
9b	10	10
South Barge Slip:		
5a	5	30
5b	15	30
7a	10	0
7b	10	15
11a	10	10
11b	10	5
SECOND ROUND OF SAMPLING (November, 1993)		
North Barge Slip:		
1a	0	5
1b	0	0
2a	0	0
2b	0	0
South Barge Slip:		
5a	0	35
5b	0	35
6a	0	65
6b	0	50

7.2.4 Tissue Data

The USFWS deployed fishnets throughout the vessel slips. Baited hoop nets were deployed at the bottom whereas baited minnow traps were deployed at the surface (USFWS, 1994). All of the gill nets established caught fish including White perch (*Morone americanus*), Alewife (*Alosa pseudoharengus*), and Gizzard shad (*Dorosoma cepedianum*). These three species represented 97% of the total number of fish collected. The different species of fish and quantities collected are shown in Table 7-3. Each species is identified as resident or migratory and as demersal or pelagic. A resident species is characterized as staying predominantly in one location whereas a migratory species is likely to migrate to other areas. Demersal species are likely to feed off the bottom (i.e. sediments) whereas Pelagic species are not. The USFWS took whole body tissue samples of three fish and analyzed them for chemical content. Results are shown in Table 7-4. A further analysis of these results will be carried out in section 8.3.2 of this report.

Table 7-3
Schools of fish and total number of fish collected (USFWS, 1994)

Common name	Scientific name	Total number	Resident/ Migratory (NSQS, 1998)	Demersal/ Pelagic (NSQS, 1998)
North Vessel Slip				
Alewife	*Alosa pseudoharengus*	17	M	P
White perch	*Morone americanus*	6	M	P
Gizzard shad	*Dorosoma cepedianum*	11	M	P
Common carp	*Cyprinus carpio*	1	R	D
Channel catfish	*Ictalurus punctatus*	1	R	D
South Vessel Slip				
White perch	*Morone americanus*	31	M	P
Gizzard shad	*Dorosoma cepedianum*	1	M	P
Common carp	*Cyprinus carpio*	3	R	D
Channel catfish	*Ictalurus punctatus*	1	R	D

Table 7-4
Fish tissue residues (mg/kg, wet weight) WSW vessel slips (USFWS, 1994)

	White perch North Slip	White perch South Slip	Common carp South Slip
PCB Aroclor 1248	0.57	0.9	1.0
PAH			
Fluoranthene	<0.025	0.046	<0.025
Pyrene	<0.025	0.038	<0.025
Metals			
Chromium	8.3	<2.1	2.0
Copper	6.4	23.5	8.9
Lead	2.2	2.7	0.64
Nickel	4.7	4.8	5.2
Selenium	<1.7	2.4	<1.4
Zinc	150	110	131

7.2.5 Macroinvertebrate Community Structure

Samples of sediments were collected at the twelve USFWS sampling stations and analyzed for benthic organisms. Benthic or macroinvertebrate community refers to the organisms dwelling at the bottom of the vessel slips. A total of four different orders of organisms were identified at the vessel slips: insecta, annelida, mollusca, and nematodes. The taxonomic identification of the organisms is shown in Table 7-5. The number of organisms found at each sampling station is shown in Table 7-6.

7.3 Ecology of Site (Potential Receptors)

For the purposes of this study, only receptors within the vessel slips were considered. These receptors included benthic organisms and fish.

7.4 Contaminant of Concern (COCs)

7.4.1 Sediment COCs

Sediment chemistry is a measure of the chemical composition of sediment-associated contaminants (NSQS, 1998). Contaminants of concern were selected by screening all existing sediment chemistry and surface water chemistry against background concentrations and sediment screening values. A chemical was considered a COC if its concentration in the vessel slips was above background concentrations, sediment screening values or both. In addition, all contaminants detected in fish tissue residues were considered as contaminants of concern. Compounds below a given detection limit were assumed to have a concentration of half of the given detection limit. If half of the detection limit was still above the extreme classification value or screening value, the chemical was determined to be a contaminant of concern. Contaminants of concern represent all chemicals that have a potential to contribute to significant ecological risks.

Table 7.5
Taxonomic identification of the organisms found in the vessel slips.

Order Insecta
  Class Dipteria
    Family Chironomidae - Midge Larvae

Order Annelida
  Class Oligochaeta - Aquatic worms

Order Mollusca
  Class Pelecypoda
    Family Corbiculidae
      Genera *Corbicula malinensis* - Asiatic clam
Order Mollusca
  Class Pelecypod
    Family Corbiculidae
      Genera *Dreissena polymorpha* - Zebra mussel
Tylenchus sp. - Nematodes

Table 7-6
Aquatic macroinvertebrates collected by the USFWS at the vessel slip sampling stations between December 1993 and February 1994. Data expressed as number of organisms per sampling station.

Taxa - # organisms/sampling station		Sampling Station											
		North Slip						South Slip					
Common Name	Scientific Name	1	2	3	4	9	10	5	6	7	8	11	12
Midge Larvae	*Chironomidae*	2	-	-	2	-	-	5	-	-	-	-	-
Aquatic worm	*Oligochaeta*	16	11	22	11	4	7	6	25	11	1	-	-
Asiatic Clam	*Corbicula malinensis*	-	-	1	-	3[5]*	3[3]	-	-	1[2]	1[99]	3[35]	1
Zebra Mussel	*Dreissena polymorpha*	-	-	2	-	[2]	-	-	-	-	-	-	-
Nematodes	*Tylenchus sp.*	-	-	-	3	-	-	-	4	-	-	-	-

* Values in [] indicate number of dead organisms found

Background concentration data from the Illinois EPA's *Evaluation of Stream Sediment Data* report (IEPA, 1984) was used to screen all sediment metal and PCB concentrations data. There were no background concentrations for PAHs available. A classification of Illinois stream sediments as reported by the IEPA is shown in Appendix D. The concentrations are classified as non-elevated, slightly elevated, elevated, highly elevated and extreme. These ranges of concentrations were based on one, two, four, and eight standard deviations from the background mean (IEPA, 1984).

Complete results of the background sediment comparison are shown in Appendix D. A summary of the maximum concentrations of metals and PCBs detected at the vessel slips versus extreme Illinois Stream Sediment concentrations is given in Table 7-7. The resulting contaminants of concern are shown in Table 7-8. Eight vessel slip concentrations of metals were above the extreme classification values. All seven vessel slip concentrations of PCBs were above the extreme classification values.

Table 7-7

Maximum concentrations of metals and PCBs compared to extreme background concentrations of Illinois Stream Sediments (IEPA, 1984)

Element	North Slip Max. (ppm)	South Slip Max. (ppm)	IEPA Classification Extreme (ppm)
Metals			
Arsenic	**42.9***	**39.7**	>28
Chromium	**256.72**	**262**	>60
Copper	**338.9**	**275.04**	>200
Iron	**164427.6**	**185467**	>50000
Lead	**770.4**	**1321.15**	>100
Manganese	**6360**	1990	>5000
Mercury	**1.008**	**1.385**	>0.30
Zinc	**2572.4**	**3502.44**	>300
Cadmium	9.4	19.5	>20.0
Element	North Slip Max. (ppb)	South Slip Max. (ppb)	IEPA Classification Extreme (ppb)
PCBs			
Aroclor 1242	**2503.7**	**8005.3**	>1500
Aroclor 1248	**<5526.3**	**<3695.7**	>1500
Aroclor 1254	992.8	**<7608.7**	>1500
Aroclor 1260	**<8604.7**	**<7608.7**	>1500
Aroclor 1016	**<5526.3**	**<8034.03**	>1500
Aroclor 1221	**<5526.3**	**<8034.03**	>1500
Aroclor 1232	**<5526.3**	**<8034.03**	>1500

* Values in bold indicate concentrations above extreme background sediment values
* < indicates concentration below given detection limit. These were assumed to be half of the given detection limit

Table 7-8

Contaminants of concern as determined by comparisons between vessel slip sediment chemistry concentration and background concentrations.

Metals	PCBs
Arsenic	Aroclor 1242
Chromium	Aroclor 1248
Copper	Aroclor 1254
Iron	Aroclor 1260
Lead	Aroclor 1016
Manganese	Aroclor 1221
Mercury	Aroclor 1232
Zinc	

Contaminants of Concern at the site were also selected by comparing the measured dry weight concentrations of contaminants in the vessel slip sediments to screening values presented in the National Sediment Quality Survey. Sediment chemistry screening values are "reference values above which a sediment ecotoxicological assessment might indicate a potential threat to aquatic life" (NSQS, 1998). The screening values used for comparison were the ARCS Effects Range Median (ER-M) and Effects Range Low (ER-L) developed by Long *et al* (1995). The ER-Ls/ER-Ms "relate the incidence of adverse biological effects to the sediment concentration of a specific chemical" (NSQS, 1998). Concentrations below the ER-L represent the minimal-effects range. Contaminant concentrations above the ER-M represent the probable-effects range. Concentrations in between the ER-Ls and ER-Ms represent possible-effects range.

For chemicals not assigned ER-Ls or ER-Ms, the measured dry weight chemical concentration was compared to a second screening benchmark, Apparent Effects Threshold or AETs. AETs "identify concentrations of contaminants that are associated exclusively with sediments exhibiting statistically significant biological effects relative to reference sediments" (NSQS, 1998). Chemical-specific screening values are included in Appendix D.

Compounds below a given detection limit were assumed to have a concentration of half of the detection limit. If half of the detection limit was still above the sediment screening values, the chemical was determined to be a contaminant of concern. It is recommended that lower detection limits be required to ensure that concentrations below the given detection limit are not contributing to exposure concentrations.

The USFWS dry chemical data were compared with the sediment chemistry screening values. A summary of the maximum concentrations of chemicals detected at the vessel slips versus screening values is given in Table 7-9. As can be seen from the table, maximum concentrations were at times an order of magnitude greater than sediment screening values. Of the chemicals detected in the North Slip, a total of 14 PAHs, 5 metals, 7 PCBs, and 2 pesticides were determined to be chemicals of concern (COCs). For the chemicals detected in the South Slip, a total of 18 PAHs, 6 metals, 7 PCBs, and 3 pesticides were determined to be chemicals of concern (COCs).

Table 7-9
Maximum concentrations (mg/kg, ppm dry weight) for sediment chemicals in the vessel slips at Wisconsin Steel Works.

Element	Maximum Concentration*	ER-M	AET-H
PAHs			
Naphthalene	**28.12**	2.1	
Acenaphthylene	**6.23**	0.64	
Acenaphthene	**10.83**	0.5	
Fluorene	**21.65**	0.54	
Phenanthrene	**122.62**	1.5	
Anthracene	**49.05**	1.1	
Fluoranthane	**175.78**	5.1	
Pyrene	**81.82**	2.6	
Chrysene	**54.18**	2.8	
Benzo[a]anthracene	**33.06**	1.6	
Benzo[b]fluoranthene	**31.62**		9.9
Bezo[a]pyrene	**31.29**		9.9
Benzo[a,h]anthracene	**68.54**	1.6	
Benzo[g,h,i]perylene	**37.15**	0.26	9.9
Indno[1,1,3-cd]pyrene	**26.09**		2.6
Acetone	0.76		
2-Butanone	0.17		
4-Methylphenol	6.49		
2-Methylnaphthalene	**4.15**		
Dibenzofuran	**5.09**	0.67	
Bis(2-ethylhexyl)phthalate	1.86		1.9
Metals			
Arsenic	42.9	70	
Cadmium	**19.5**	9.6	
Chromium	256.72	370	
Copper	**338.9**	270	
Iron	185467		
Lead	**1321.2**	218	
Mercury	**1.385**	0.71	
Nickel	**160.6**	51.6	
Zinc	**3502.4**	410	
Total Cyanide	13.49		
PCBs			
Aroclor 1242	**8.01**	0.18	
Aroclor 1248	**0.81**	0.18	
Aroclor 1254	**0.99**	0.18	
Aroclor 1260	**0.41**	0.18	
Aroclor 1016	**<8.03**	0.18	
Aroclor 1221	**<8.03**	0.18	
Aroclor 1232	**<8.03**	0.18	
Pesticides			
4,4'-DDE	**0.04081**	0.027	
4,4'-DDD	**<0.326**	0.027	
4,4'-DDT	**<0.553**	0.027	

* Values in bold indicate concentrations above sediment screening values

The COCs in the sediment for the North and South Slips as determined by comparisons with screening values are presented in Table 7-10. A brief synopsis of the chemicals detected follows.

Table 7-10
Contaminants of concern as determined by comparisons between vessel slip sediment chemistry concentration and screening values.

PAHs	Metals	PCBs	Pesticides
Naphthalene	Cadmium	Aroclor 1242	4,4'-DDE
Acenaphthylene	Copper	Aroclor 1248	4,4'-DDD
Acenaphthene	Lead	Aroclor 1254	4,4'-DDT
Fluorene	Mercury	Aroclor 1260	
Phenanthrene	Nickel	Aroclor 1016	
Anthracene	Zinc	Aroclor 1221	
Fluoranthane		Aroclor 1232	
Pyrene			
Chrysene			
Benzo(a)anthracene			
Benzo(b)fluoranthene			
Benzo(k)fluoranthene			
Bezo(a)pyrene			
Benzo(a,h)anthracene			
Benzo(g,h,i)perylene			
Indno(1,1,3-cd)pyrene			
2-Methylnaphthalene			
Dibenzofuran			

North Slip

Metals

Five metal concentrations from the North Vessel Slip were found to be above sediment screening criteria: copper, lead, mercury, nickel, and zinc. Of the three North Slip sections, the West End contained the highest concentration of metals. There was not a noticeable difference in the range of metal concentrations between the North and South Vessel Slips.

PAHs

Fourteen PAH concentrations from the North Vessel Slip were found to be above sediment screening criteria: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo[a]pyrene, benzo[a,h]anthracene, indno[1,2,3-cd]pyrene, 2-Methylnaphthalene, and dibenzofuran.

PAHs acenaphthene, and dibenzofuran were below a given detection limit. However, half of that detection limit concentration was still above screening values. As a result, these two PAHs were included as COCs in the North Vessel Slip, albeit being below detection limit. Lower detection limits standards are recommended to assure that concentrations below detection limits are not contributing to hazard exposure concentrations. PAH concentrations varied slightly between North Slip sampling stations, however, there were not any group trends for the variation.

PCB Aroclors

Four PCB Aroclors (1242, 1248, 1254, and 1260) were detected in the North Vessel Slip. PCB Aroclor 1242 was detected in the West and East End of the North Slip. PCB Aroclor 1248 was detected in the East End of the North Slip. PCB Arochlor 1254 was detected throughout the North Slip, while PCB Arochlor 1260 was detected in the west and east sections of the North Slip. The remaining three Aroclors were below a given detection limit. The concentrations of these three Aroclors were then assumed to be half of the detection limits, which were still above sediment screening values. As a result, a total of seven PCB Aroclors were determined to be contaminants of concern in the North Slip. Refer to Appendix D for a detailed presentation of PCB concentrations.

VOCs

ER-M screening concentrations were unavailable for VOCs. As a result, all measured VOC concentrations in vessel slip sediments were screened against AET-H values. All VOCs were below given detection limits. The concentrations were then assumed to be half of the detection limits which were below AET-H values. As a result, no VOC's were included amongst the contaminants of concern for the slips.

Pesticides

Two pesticide concentrations were identified as being above ER-M values: 4,4'-DDE and 4,4'-DDT. Again, both pesticides were below detection limits. The concentrations were then assumed to be half of the detection limits whish were above ER-M concentrations. They were therefore considered as COCs for the North Vessel Slip.

South Slip

Metals

Six metal concentrations for the South Slip were detected to be above sediment screening criteria: cadmium, copper, lead, mercury, nickel, and zinc. We should note that the sediment chemistry data for the middle section of the South Slip (sampling stations 7 and 8) was missing or was not included in the original USFWS report. As a result, we have no data on the sediment metal concentrations at the middle of the South Slip. It is recommended that additional sampling be carried out at this section as it could contain contaminant "hot spots".

PAHs

Eighteen PAH concentrations in the South Slip were found to be above sediment screening criteria. The sediment PAH concentrations for the East End of the South Slip (at confluence of vessel slip and Calumet River) were among the highest in comparison to both vessel slips.

PCB Aroclors

One PCB Arochlor (1242) was detected throughout the south vessel slip. The remaining six Aroclors were below a given detection limit. They were thus assigned concentrations of half of the detection limit. When compared against ER-M values, concentrations of half of the detection limit were higher. As a result, all seven PCB Aroclors were determined to be contaminants of concern.

VOCs

A total of five volatile aromatics (benzene, toluene, m-xylene, o-xylene, and p-xylene) were detected in the West End of the South Slip. These concentrations were below sediment screening values. Toluene was also detected in the middle section of the South Slip. It is important to note that a very high concentration of toluene (2000 ppb dry weight) was detected in sampling station number 7 when compared to other sampling stations. This might indicate a toluene "hot spot" particularly since the toluene concentration at sampling station 8 (situated no more than 6 feet apart) was much lower at 13.7 ppb. However, the elevated concentration of toluene was still below sediment screening values and was not considered a contaminant of concern.

Pesticides

Three pesticides (4,4'-DDD, 4,4'-DDE, and 4,4'-DDT) were above screening ER-M values. Only one concentration of 4,4'-DDE in the West End of the south vessel slip was above ER-M values. The remaining concentrations were below detection limit and assumed to be half of the given detection limit. The resulting concentrations were still above ER-M values and were thus also considered as COCs.

Final contaminants of concern taking into consideration comparisons to background concentrations, sediments screening concentrations as well as contaminants found in fish tissue are shown in Table 7-11 below. Final Contaminants of Concern included 18 PAHs, 9 metals, 7 PCBs, and 3 pesticides.

Table 7-11
Final Contaminants of concern for the Wisconsin Steel Works vessel slips.

PAHs	Metals	PCBs	Pesticides
Naphthalene	Cadmium	Aroclor 1242	4,4'-DDE
Acenaphthylene	Copper	Aroclor 1248	4,4'-DDD
Acenaphthene	Lead	Aroclor 1254	4,4'-DDT
Fluorene	Mercury	Aroclor 1260	
Phenanthrene	Nickel	Aroclor 1016	
Anthracene	Zinc	Aroclor 1221	
Fluoranthane	Arsenic	Aroclor 1232	
Pyrene	Chromium		
Chrysene	Selenium		
Benzo(a)anthracene			
Benzo(b)fluoranthene			
Benzo(k)fluoranthene			
Bezo(a)pyrene			
Benzo(a,h)anthracene			
Benzo(g,h,i)perylene			
Indno(1,1,3-cd)pyrene			
2-Methylnaphthalene			
Dibenzofuran			

7.4.2 Surface Water COCs

Metals and trace levels of benzene and chloroform were detected in the water samples. The samples were screened against USEPA Ambient Water Quality Criteria (AWQC) for freshwater organisms. There are two criteria available for comparison:

CMCs (Criteria Maximum Concentrations) or CCCs (Criterion Continuous Concentrations). CMCs represent the highest concentrations of chemicals in surface water to which an aquatic community can be exposed briefly without resulting in adverse effects. CCCs are criteria that estimate the highest concentrations to which aquatic organisms can be exposed indefinitely without resulting in unacceptable adverse effects (USEPA, 1999). Vessel slip measured concentrations of chemicals were screened against CCCs to ensure the protection of aquatic organisms when exposed indefinitely to the surface water in the vessel slips. Results of the screening of vessel slip surface water are shown in Appendix E. Three metals (aluminium, cadmium and lead) were above CCC values throughout all three sections of the North Vessel Slip. Aluminium concentrations were above CCC values throughout the south vessel slip. Lead concentrations in the East End of the South Slip were found to be above CCC values. Thus lead and aluminium concentrations in the surface water of both vessel slips are above the AWQC criterion indicating elevated levels which could potentially cause adverse effects on the aquatic organisms when exposed indefinitely to the surface waters of the vessel slips. A summary of surface water COCs is given in Table 7-12. Note that the middle section of the south vessel slip was not sampled.

Table 7-12
Concentrations of surface water COCs versus AWQC values (IEPA, 1996)

Chemical	AWQC	North Slip			South Slip		
	CCC (µg/L, ppb)	West (ppb)	Middle (ppb)	East (ppb)	West (ppb)	Middle (ppb)	East (ppb)
Aluminium	87	334	208	295	574	NA	654
Cadmium	2.2	<4	<4	4.3	ND	NA	ND
Lead	2.5	3.1	3.3	2.6	4	NA	4.1

NA: Not Available (middle section of south vessel slip was not sampled)
ND: Not Detected

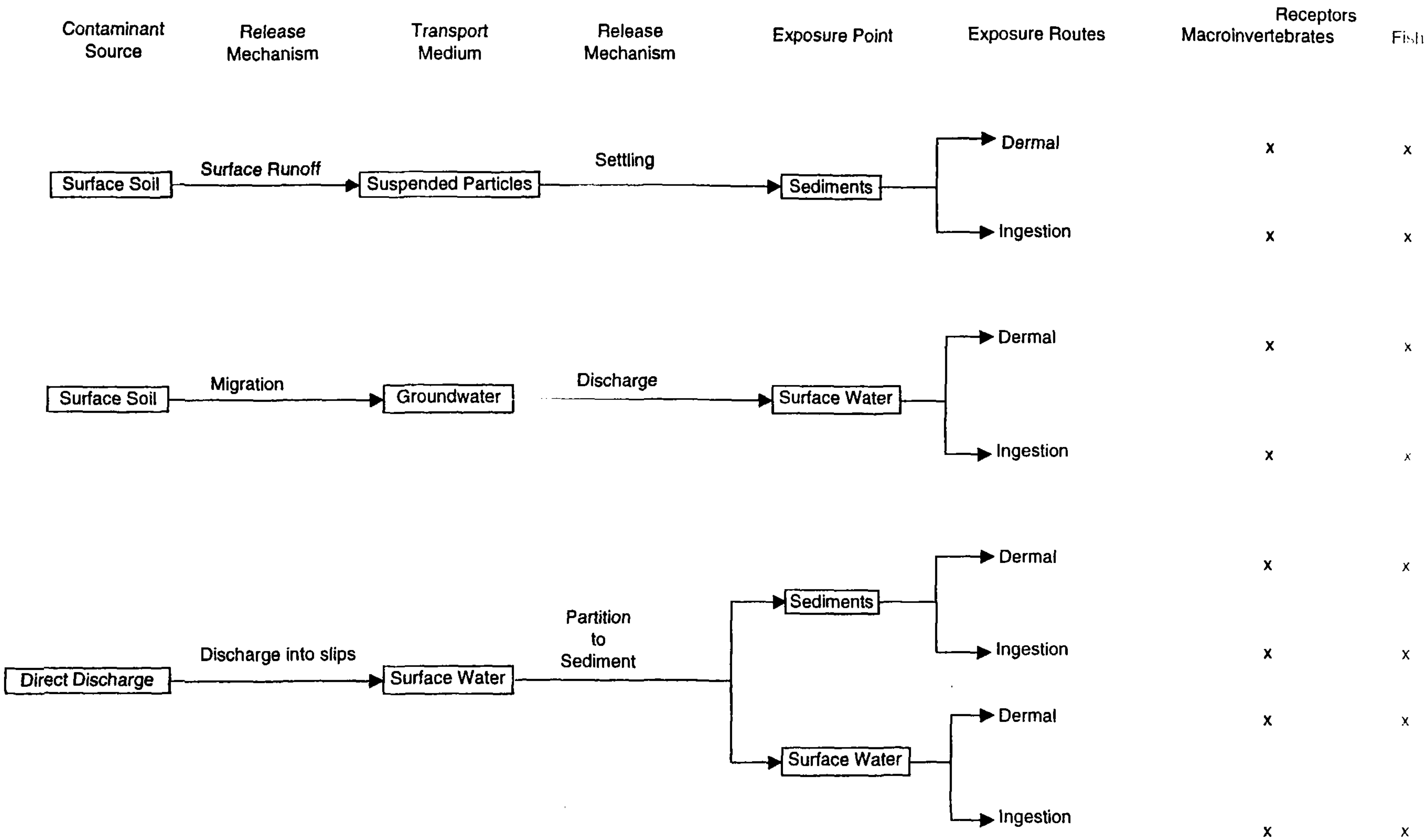
8.0 Ecological Effects Assessment

8.1 Exposure Pathways

A conceptual model of the site incorporates a description of how contaminants move through the physical environment and biotic food webs to reach an organism. It therefore identifies key exposure pathways, which in turn link potential adverse effects to contaminants found on the site. As described in the ARCS Risk Assessment and Modeling Overview Document, "for a pathway to be complete, a contaminant must be able to travel from the source to the ecological receptors and to be taken up by the receptors via one or more exposure routes" (USEPA, 1993). For aquatic organisms, exposure routes include direct contact with water or sediment from the vessel slips and ingestion of food or sediments. A contaminant will migrate through surface water or groundwater to the vessel slips. The process of phase partitioning and transport of particulates will distribute the chemical throughout the vessel slips. If an exposure pathway is not complete, it is discarded from further analysis.

The exposure pathways for the WSW vessel slips are shown on Figure 8-1. The two primary sources of potential contamination are surface soil (from WSW site) and direct discharge (from past transporting activities to and from the site). A variety of hazardous contaminants associated with coking operations were detected in the soil and groundwater of the site. These included heavy metals, PAHs, phenols, PCBs, benzene, xylene and toluene (NU, 1998). Groundwater on the site flows to the North and South Vessel Slips and the Calumet River. Further, it was determined by past studies that the water table was particularly high (5-10 feet below surface) implying that soluble contaminants in the soil would migrate quickly through the soil to the groundwater (NU, 1998). Thus contaminants in the soil can migrate through either surface runoff or groundwater to reach the vessel slips. Through settling of suspended particles (associated with soil particles from surface runoff), the contaminants would reach the bottom sediments in the vessel slips. Groundwater discharge would lead to contaminants being distributed in the surface water. Direct discharge has the potential to be either settled out (through phase partitioning) or to remain in the surface water.

Figure 2: Exposure Pathways



Two additional exposure pathways were excluded in Geraghty & Miller's 1999 Ecological Risk Assessment Former Wisconsin Steel Works. The primary sources of these two exposure pathways were Calumet River water and sediment. These were not included in this report as there was insufficient data to analyze the possibilities. Data on surface water and sediment transport from the Calumet River into the vessel slips would be needed. This data was no available at the time this report was prepared. As a result, the exposure pathways were not included in the risk assessment.

For the scope of this study, receptors included macroinvertebrates and fish. A study of aquatic plants was not included. However, it is recommended that further studies be carried out to assess the effects of sediment-derived chemicals on aquatic plants, as they are an integral part of the ecology of the vessel slips. Both macroinvertebrates and fish are in direct contact with sediments, interstitial (or pore) water, and surface water. Some species of macroinvertebrates (oligochaeta and chironomidae) are known to be sediment ingesters. As a result, macroinvertebrate uptake of contaminants could lead to transfer of these contaminants to higher trophic organisms (through the food chain, as a result of ingestion of lower trophic organisms such as macroinvertebrates).

8.2 Toxicity Analysis of Contaminants

8.2.1 Analysis of PAH Toxicity

In natural waters, PAHs can be present in the form of colloidal suspension (sorbed to suspended particulates). Accumulation of PAHs from sediment is also possible since many benthic organisms (deposit feeders) feed on organic materials present in the sediments. Bioaccumulation of PAHs by benthic organisms poses a health hazard to their predators consisting of higher trophic organisms such as fish.

PAHs interact physically with hydrophobic sites in the cell, causing molecular deformation. PAHs can be metabolized by aquatic organisms to polar, water-soluble metabolites, which are more readily excreted than the parent PAHs. However, these metabolites, while being more hydrophilic, are also more reactive and many undergo several enzyme chemical reactions which may lead to bonding of the PAH metabolite to cellular macromolecules such as proteins and DNA (Rand, 1985). This bonding results in mutagenesis, teratogenesis, and cancer in the organism. Toxicity of PAHs increases as the molecular weight increases within a certain range. PAHs in the molecular weight range from naphthalene (128) to fluoranthene and pyrene (202) are acutely toxic to organisms (Rand, 1985). HPAHs are not as acutely toxic because they are not as bioavailable to organisms as they don't dissolve at the concentrations required for adverse effects. Long term exposure to PAHs may also result in sublethal effects, which result in a reduction of the organism's capacity to survive in the water environment. Total PAHs are acutely toxic to aquatic organisms at aqueous concentrations of about 0.2 to 10 ppm whereas sublethal responses are generally observed at a concentration range of 5-10 ppb (Rand, 1985). Total aqueous concentrations of PAHs as calculated using an equilibrium partitioning model (discussed in section 8.3.1) ranged from 170 ppb to 700 ppb. Thus aqueous concentrations of PAHs have a potential to cause sublethal responses. Although concentrations are on the lower end of the scale for acute toxic effects, they are still within the range and thus have a potential to cause acute toxic effects to fish.

8.2.2 Analysis of PCB Toxicity

LC_{50} values for Aroclor 1248 and 1254 (both considered contaminants of concern at the WSW vessel slips) are shown in Table 8-1. LC_{50} values represent concentration of the chemical at which 50 percent of the exposed population dies. Results are shown for different exposure durations.

Table 8-1
LC_{50} concentrations for PCB Aroclor 1248 and 1254

Chemical	Species	LC_{50} (µg/L)	Exposure Duration (days)	Source
PCB Aroclor 1248	Channel Catfish (*Ictalunus punctatus*)	121-225	10	Mayer, 1977 Stalling, 1972
PCB Aroclor 1248	Channel Catfish (*Ictalunus punctatus*)	57-127	15	Mayer, 1977 Stalling, 1972
PCB Aroclor 1254	Channel Catfish (*Ictalunus punctatus*)	303-741	10	Mayer, 1977 Stalling, 1972
PCB Aroclor 1254	Channel Catfish (*Ictalunus punctatus*)	1.76	4	Birge, 1978

For PCB Aroclor 1248, LC_{50} values for a 10-day exposure of Channel catfish (*Ictalurus punctatus*) to PCBs suspended in water ranged from 121 to 225 ppb. LC_{50} concentrations decreased as the exposure duration increased. That is, for longer exposure duration, lethal effects to organisms required less concentration of the contaminant. This might suggest that the chronic adverse effect of PCB 1248 on the organism in question (channel catfish) is more severe than the acute (or short-term) adverse effect. The West and East End of the North Slip had sediment concentrations above these LC_{50} values. Maximum calculated concentrations of PCB Aroclor 1248 ranged from 8.12E-4 to 0.003 ppb. These values were calculated using an equilibrium-partitioning model which will be discussed in section 8.3.1. Aqueous concentrations of PCBs in vessel slip surface or pore water do not seem to be acutely lethal to the fish species Channel Catfish.

PCB Aroclor 1254 had LC_{50} values ranging from 280 to 741 ppb (for a 15-day exposure of channel catfish to PCBs suspended in water). The 4-day LC_{50} value was 1.76 ppb suggesting that the acute (or short-term) adverse is more severe than the long-term or chronic effect (opposite that of PCB Aroclor 1248). This lethal LC_{50} dose is above vessel slip aqueous concentrations of Aroclor 1254 (calculated using equilibrium partitioning model in section 7.3.1). Thus we can conclude that calculated vessel slip concentrations of PCB Aroclor 1254 do not represent a lethal dose to the particular species Channel Catfish (found in the vessel slips).

8.2.3 Analysis of Metal Toxicity

Many trace metals play an essential role as micronutrients to organisms. These include copper, chromium, iron, manganese, nickel, selenium and zinc. However, large doses of these essential micronutrients can have acute as well as chronic toxicity manifested as reduction in growth rate or death. Embryonic and larval stages of organisms are the most sensitive stages of a life cycle to these metals (Rand, 1985). Nonessential trace elements include lead, cadmium and mercury. Shown on Tables 8-2 and 8-3, are LC_{50} concentrations of mercury, copper, zinc, nickel, cadmium, and chromium to White perch and Common Carp (species of fish found in the WSW vessel slips). These LC_{50} concentrations were derived in experiments where the temperature was kept at 28 °C (Rehwoldt, 1972). This closely resembles the conditions in the vessel slips since the temperature range was 21 to 27 °C (USFWS, 1994).

Table 8-2
Metal LC_{50} concentrations for White perch (*Morone americana*) (Rehwoldt *et al.*, 1971 and 1972)

Chemical	LC_{50} (µg/L)	Exposure Duration (days)
Mercury	240	1
Mercury	22	4
Copper	11500	1
Copper	6400	4
Zinc	13500	1
Zinc	14400	4
Nickel	18400	1
Nickel	13700	4
Cadmium	1600	1
Cadmium	8400	4
Chromium	17500	1
Chromium	14400	4

Table 8-3
Metal LC_{50} concentrations for Carp (*Cyprinus carpio*) (Rehwoldt *et al.*, 1972)

Chemical	LC_{50} (µg/L)	Exposure Duration (days)
Mercury	330	1
Mercury	180	4
Copper	1900	1
Copper	800	4
Zinc	14400	1
Zinc	7800	4
Nickel	38300	1
Nickel	10400	4
Cadmium	450	1
Cadmium	240	4
Chromium	21200	1
Chromium	14300	4

For all the metals shown in Tables 8-2 and 8-3, LC_{50} concentrations increased for shorter periods of exposure. The effects associated with chronic exposure (long-term) are therefore more significant than the toxicity posed by short-term or acute exposure. Mercury is much more toxic than any other metal shown. Zinc, copper, and nickel are all essential micronutrients. As a result, the concentrations at which they become lethal to organisms are much higher than that of mercury. Mercury toxicity appears to involve cell membranes and affect membrane permeability (Rand, 1985).

Concentration of zinc in cells can govern many metabolic processes, specifically carbohydrate, fat, and protein metabolisms and nucleic acid synthesis and degradation. Exposure to aqueous zinc at 0.5 to 1.2 ppm for 24 hours significantly depressed mean white blood cells in salmon (Rand, 1985).

Once again, toxicity of certain metals might increase with increased temperatures. A study done on cadmium toxicity to macroinvertebrate oligochaetes showed that tolerances of all species tested with cadmium at 1 °C and pH 6 were significantly elevated in comparison to 10 °C and pH 7 (Chapman, 1981). This is of significance because the temperature of the water in the South Vessel Slip is elevated due to the discharge of cooling water from Acme Steel. The water temperature in the vessel slips ranged from 21 °C in the North Vessel Slip to 27 °C in the South Vessel Slip. Thus toxicity of metals to organisms may increase when the water in the vessel slips becomes elevated (during summer months), particularly in the South Vessel Slip where water temperatures may be elevated throughout the year due to the discharge of cooling water.

8.3 Impact Evaluation

8.3.1 Analysis of Toxicity Tests

As described in section 7.2.3, the USFWS performed fish toxicity tests using larval Fathead minnows as indicator organisms. Toxicity tests provide a direct measure of the effects of contaminated sediment on aquatic organisms. They measure biological responses directly and include possible interactions between mixtures of sediment-derived chemicals. In interpreting the USFWS results, toxicity tests that had control mortality greater than 10% were excluded from further consideration. This was in accordance to EPA requirements indicating that controls should have less than a 10% mortality rate (NSQS, 1998). Test responses were considered to be indicative of effects if they were 20% or more above the control response. Results of fish toxicity tests were presented in Table 7-2.

During the first round of sampling, the majority of controls had mortalities at or above the 10% limit. Station number 1b, 3b, and 5b exhibited inadequate controls and were therefore excluded from further analysis. The remaining sampling stations showed no significant toxicity. Toxicity tests were repeated in a second round performed in November of 1993. The North Vessel Slip did not exhibit any toxicity to the fish. The South Vessel Slip sampling stations 5 and 6 (West End) were found to be acutely toxic to fish, exhibiting mortalities in the range of 35 to 65%.

Bioassay water quality was monitored for pH, dissolved oxygen (D.O.), temperature, and ammonia concentrations. All conditions were normal with the exception of elevated un-ionized ammonia levels. In aqueous solutions, ammonia assumes two chemical forms: un-ionized ammonia ($NH_3 \cdot nH_2O$) and ammonium (NH_4^+).

$$NH_3 + nH_2O = NH_3 \cdot nH_2O = NH_4^+ + OH^- + (n-1)\, H_2O$$

The concentration of ammonia depends on several factors, including pH, and temperature (°C). As the pH of the solution increases, the equilibrium is shifted to the left, producing more un-ionized ammonia ($NH_3 \cdot nH_2O$). Un-ionized ammonia is acutely toxic to fish. Toxicity effects include gill ventilation, hyperactivity, convulsions, and then death (Rand, 1985). The presence of other contaminants also increases the lethality of ammonia. Synergistic effects occur in solutions containing both ammonia and zinc (Rand, 1985).

Sampling station 12 was not used to perform toxicity tests. This station was found to contain the highest concentrations of PAHs and metals in the vessel slips. It is therefore the recommendation of this report that further toxicity tests be carried out using sediments from sampling station 12.

Most of the mortality at sampling stations 5 and 6 occurred at the 24-hour mark. Total ammonia concentrations ranged between 9.1 to 17 mg/l. These values were above the LC_{50} concentrations for a 4-day exposure of 5.9 to 8.2 ppm. It is likely that the high ammonia concentration is adversely affecting the fish. However, we cannot rule out possible synergistic effects between the ammonia and other contaminants found in the sediments. In addition, the high ammonia concentrations might be masking other lethal effects occurring from sediment-derived contaminants.

In order to clarify the role of ammonia and COCs in the mortality endpoint, correlation analyses were carried out. Results of these analyses will allow us to pinpoint specific chemicals (including un-ionized ammonia) which exhibit a strong relationship with mortality of fish.

The USFWS regularly measured the aqueous concentration of un-ionized ammonia. However, the aqueous concentrations of COCs were not measured. As a result, an equilibrium partitioning model was used to derive chemical concentrations in the water given the concentrations in the sediment phase. The methodology as well as the results is shown in Appendix H. The model is limited to PAHs and PCBs since metals are not assigned k_{oc} values. Correlation analyses were therefore limited to PAHs, PCBs, and un-ionized ammonia concentrations. Both the 0 to 48-hour mortality and the 48 to 96-hour mortality were correlated to un-ionized ammonia concentrations (at 48 hours and 96 hours) and calculated aqueous concentrations of COCs. Results from the analyses show a strong correlation between 48-hr un-ionized ammonia concentrations and % mortality (r^2= 0.86). However, naphthalene (r^2= 0.80) and fluorene (r^2=0.64) also exhibit a strong correlation. This indicates that toxicity caused by chemicals other than ammonia cannot be ruled out. A summary of the correlation results is shown in Table 8-4 below. For a more detailed description, please refer to Appendix H. A second correlation analysis was carried out using 48 to 96 hour mortality. Ammonia concentrations at 96 hours and calculated concentrations of COCs were used. Results are shown in Table 8-4 below. Naphthalene exhibited the strongest correlation (r^2=0.61), followed by ammonia (r^2=0.50), and fluorene (r^2=0.50). It is likely that the high ammonia concentration in the 48-hr mark is masking the toxicity effects of other chemicals in the bioassay water. This becomes apparent when we observe the results from the 48 to 96 hour correlation analyses. Un-ionized ammonia concentrations are lower in this time range yet we still see Fathead minnow mortality. Results show that deaths in this time range are more likely due to naphthalene (r^2=0.61) than to un-ionized ammonia concentrations (r^2=0.50). Thus toxicity caused by chemicals other than un-ionized ammonia cannot be ruled out.

Table 8-4
Correlation between fish tissue analyses and aqueous concentrations of PAHs, PCBs and un-ionized ammonia.

Chemical	0-48 hour r^2	48-96 hour r^2
Ammonia	0.86	0.50
Naphthalene	0.82	0.61
Fluorene	0.64	0.38
Benzo(a)pyrene	0.49	0.34
Acenaphthene	0.45	0.34
Anthracene	0.43	0.39
Aroclor 1254	0.32	0.15

To further assess this correlation, calculated aqueous concentrations of PAHs can be compared to Ambient Water Quality Criteria (AWQC). However, these were not available in the literature search. A document (USEPA, 1980) was found to contain AWQC for PAHs, however, this document was not made available in time for this report. It is recommended that this document be consulted to compare calculated aqueous concentrations to AWQC.

8.3.2 Analysis of tissue data

Chemicals with a low solubility in water generally have a high affinity for lipids (fatty tissue) and can therefore be stored and concentrated in tissues with a high lipid content (Rand *et al.*, 1985). The USFWS took whole body tissue samples of three fish and analyzed them for chemical content. Results of tissue residue analyses were compared against Tissue Screening Concentrations (TSCs). TSCs are tissue residues in aquatic organisms, which, if exceeded, may be associated with adverse toxicological or ecological effects (NSQS, 1998). TSCs are not site or species-specific indicators and are therefore applicable as a screening tool to different sediment samples. Table 8-5 shows the results of comparison. Only three TSCs were found in the literature search. It is recommended for future work that all TSCs be found in order to be able to better analyze the results of the tissue data.

Table 8-5
Comparison of measured tissue residue concentrations with Tissue Screening Concentrations (mg/kg, wet weight) (NSBC, 1996)

Chemical	White Perch North Slip	White Perch South Slip	Common Carp South Slip	TSC
PCB Aroclor 1248	0.57	0.9	1.0	0.44
PAHs				
Flouranthene	<0.025	0.046	<0.025	
Pyrene	<0.025	0.038	<0.025	
Metals				
Chromium	8.3	<2.1	2.0	
Copper	6.4	23.5	8.9	3
Lead	2.2	2.7	0.64	
Nickel	4.7	4.8	5.2	
Selenium	<1.7	2.4	<1.4	
Zinc	150	110	131	20

Copper, PCB Aroclor 1248, and zinc were above TSC values in all three composites of fish tissues. These tissue concentrations may therefore be associated with adverse toxicological and ecological effects in fish. As indicated in table 7-3, Common carp is a resident species (staying predominantly in one location). It therefore cannot be argued that all tissue concentrations originated from sites other than the vessel slips. The chemical concentrations in Common carp tissue are likely to originate from exposure to South Vessel Slip sediments, surface waters, or food.

In order to estimate the potential body burden of other sediment-associated contaminants in aquatic organisms (particularly fish), we used an equilibrium partitioning bioaccumulation model. Bioaccumulation data can help determine the bioavailability of sediment-derived chemicals to receptor organisms (NSBC, 1996). The model assumes that the sediments are the only source of contamination to the organisms. The theoretical bioaccumulation potential (TBP) calculations thus focus on the equilibrium distribution of the chemical between the sediments and the fatty tissues of the organism. This calculation is used as a screening mechanism to represent the magnitude of bioaccumulation potentially associated with contaminants found in the sediments of the vessel slips. The bioaccumulation potential can be estimated from the dry weight concentration of contaminants in sediments, fish lipid content, and the relative affinity of the chemical to fatty tissues (or lipid content) in fish versus its affinity for carbon in the sediments. Several assumptions are built in the model. The partitioning model assumes that the organic carbon is the only sink for the contaminants in the sediments. The model also assumes that lipids are the only sink for contaminants in the organisms. The theoretical bioaccumulation concentration is calculated using the equation shown in Table 8-6. For a sample calculation, please refer to Appendix G. Both the f_{lipid} (species-specific fish lipid content) and BSAF (Biota to Sediment Accumulation Factor) parameters were obtained from the *National Sediment Quality Survey* (Appendix G). We used EPA selected BSAFs that represented a central tendency, suggesting approximately a 50 percent chance that an associated tissue residue level would exceed a screening risk value (NSQS, 1998). Calculations were carried out for three species of fish found in the sediments (White perch, Alewife, and Common carp). Common carp has the highest percentage of lipid content (17.5% by weight) and therefore exhibits higher theoretical concentrations of PAHs and PCBs in its tissues. Results from the equilibrium model are shown in Appendix G. These calculated values thus represent the potential concentrations of contaminants, which could accumulate in fish tissues.

Table 8-6

Equilibrium Partitioning Bioaccumulation Model - equation to calculate the potential fish concentrations of contaminants from sediment concentrations, using biota-to-sediment accumulation factor.

$$C_{fish} = \frac{C_{sb} * f_{lipid} * BSAF}{TOC_{sed}}$$

C_{fish}	Concentration of chemical in fish tissue (mg/kg)	Calculated
C_{sb}	dry weight concentration of chemical sorbed to the sediments (mg/kg)	Appendix D
f_{lipid}	fish lipid content expressed as a decimal fraction (unitless)	Appendix G
BSAF	Chemical-specific Biota to Sediment Accumulation Factor (unitless)	Appendix G
TOC_{sed}	Fraction of organic carbon found in sediments expressed as a decimal fraction (unitless)	Appendix D

8.3.3 Analysis of macroinvertebrate community structure

The USFWS analyzed sediment samples for benthos community structure. Benthos refers to bottom dwelling organisms. Benthic invertebrates are a good indicator of the impact of contaminants on the ecology of the vessel slips because they are continuously exposed to surficial sediments. Macroinvertebrates are generally sedentary organisms as they complete all of their life cycle in the aquatic environment. As a result, they are representative of local conditions, integrating both the effects of short-term pollution events and long-term water quality in the vessel slips (USEPA, 1994a). Macroinvertebrates are also an integral part of an ecosystem as they are essential to the food web.

Macroinvertebrate community structure assessment provides direct evidence of the effects of sediment-derived contaminants on naturally occurring communities (USEPA, 1994a). However, effects on communities may also be due to other factors attributable to sediment type (such as sediment grain size). It is therefore crucial to select an appropriate reference site with which the results of the analysis can be compared to. According to the ARCS Program, "a reference site should be unaffected or minimally affected by anthropogenic influences" (USEPA, 1994a). However, due to the difficulty of finding a completely undisturbed environment, it is generally accepted to use a less contaminated site as the reference area. For the purposes of this study, the Calumet River was chosen as the reference area. The Calumet River has historically been used as a transport route for vessels to and from Lake Michigan. Although it is not an example of a pristine environment, conditions are assumed to be less affected than conditions at the vessel slips. The reference area is in close proximity to the vessel slips and is expected to have similar physical and chemical characteristics of both water and sediment as the vessel slips. This should minimize the differences arising from such characteristics on benthic communities at the study site.

The USFWS took sediment samples from the sampling stations and sorted through them to collect the benthic organisms. They then carried out a taxonomic identification and enumeration of the organisms. However, the data is somewhat limited, as in some instances, the particular genus of the organisms was not identified. This is important, as there are intolerant and tolerant taxa within most of the classes of organisms. The class Oligochaeta (order Annelida) is considered to be generally tolerant to organic enrichment as well as metal contamination in sediments. However, there are varying degrees of tolerances amongst different genus of Oligochaeta. As an example, the genus *Chironomus* is known to be more tolerant of organic enrichment than the genus *Polypedilum*. *Limnodrilus hoffmeisteri* is also known to be amongst the most tolerant Oligochaete species (USEPA, 1994a). Amongst the class Dipteria, the genera *Chironomus*, *Cryptochironomus*, and *Procladium* are generally considered to be the most abundant chironomid genera in heavily contaminated environments. On the other hand, the genera *Tanytarsus* prefers less organically enriched environments. It is the recommendation of this report that new samples be taken at the vessel slips with the appropriate classification of taxa in order to better represent the benthic community in the vessel slips and therefore the degree of contamination associated with it.

A number of different qualitative metrics were used for the analysis of the results. These included abundance, composition, organism's functional feeding groups and pollution tolerance. Abundance is the total number of organisms present in the samples. The number of different types of organisms (taxa) present, is representative of the diversity of the macroinvertebrate community. Composition of the community is defined as the percent contribution of major taxa. Functional feeding groups are indicative of a species relative tolerance to pollution. Comparisons between the vessel slip's macroinvertebrate community structure and the reference areas are carried out in the abundance and richness analysis. Correlations are also done between numerical abundance and sediment chemistry.

Abundance

Data is presented in the USFWS report as total number of organisms per sampling station. The data in the reference areas are presented as total number of organisms per m^2 of sediment. To be able to compare the USFWS results to the reference areas, the value for the number of organisms per sampling station was normalized to the area collected from the sediments as follows:

$$\frac{\#\text{ organisms}}{m^2} = \frac{\#\text{ organisms}}{\text{sample}} \left(\frac{1 \text{ sample}}{0.05\ m^2\ *} \right)$$

* Sediment samples taken with a nine-inch ponar grab sampler which collects 0.05 m^2 per sample taken (Source: USEPA, 1994a).

The results from these calculations are shown in Table 8-7. As can be seen from the table, aquatic worms (Oligochaeta) dominate the benthic community. The number of organisms collected from the vessel slips were in the order of only 2 to 3 percent of organisms collected at the reference area. Thus, the vessel slips have a relative scarce community when compared to the Calumet River reference area, suggesting that the level of contamination of the vessel slips could potentially be affecting the benthic community abundance. Comparisons are shown on Table 8-8.

Table 8-7

Aquatic macroinvertebrates collected by the USFWS at the vessel slip sampling stations between December 1993 and February 1994. Data expressed as number of organisms per m2 of sediment collected.

Taxa - # organisms/m2		Sampling Station													
		North Slip							South Slip						
Common Name	Scientific Name	1	2	3	4	9	10	Average	5	6	7	8	11	12	Average
Midge Larvae	*Chironomidae*	40	-	-	40	-	-	13	100	-	-	-	-	-	17
Aquatic worm	*Oligochaeta*	320	220	440	220	80	140	237	100	500	220	20	-	-	140
Asiatic Clam	*Corbicula malinensis*	-	-	20	-	60[100] *	60[60]	23	-	-	20 [40]	20 [1980]	60 [700]	20	20
Zebra Mussel	*Dreissena polymorpha*	-	-	40	-	[40]	-	7	-	-	-	-	-	-	0
Nematodes	*Tylenchus sp.*	-	-	-	60	-	-	10	-	80	-	-	-	-	13

* Values in [] indicate number of dead organisms found

Table 8-8

Percent contribution of taxa to the total number of taxa collected in grab samples from Wisconsin Steel Works vessel slips between December 1993 and February 1994.

Taxa - % contribution		Sampling Station											
		North Slip						South Slip					
Common name	Scientific name	1	2	3	4	9	10	5	6	7	8	11	12
Aquatic Worm	*Oligochaeta*	89%	100%	88%	69%	57%	70%	55%	86%	92%	50%	-	-
Midge Larvae	*Chironomidae*	11%	-	-	12%	-	-	45%	-	-	-	-	-
Mollusca	*Bivalvia*	-	-	12%	-	43%	30%	-	-	8%	50%	100%	100%
Nematodes	*Tylenchus sp*	-	-	-	19%	-	-	-	14%	-	-	-	-
Mean Abundance of all live benthic organisms (number/sampling station)		18	11	25	16	7	10	11	29	12	2	3	1

Table 8-9

Comparison of total abundance of benthic organisms collected at WSW vessel slips (December 1993-February 1994) with reference area (center of Calumet River at 95th street, collected in June 1991).

Taxa - #organisms/m2	Wisconsin Steel Works North Slip	Wisconsin Steel Works South Slip	Reference area: Calumet River at 95th Street
Oligochaeta - Aquatic worm	237	140	9162
Chironomidae - Midge larvae	13	17	767
Mollusca (Asiatic clam & Zebra mussel)	30	20	266
Tylenchus sp. - Nematodes	10	13	
Turbellaria	0	0	32
Total abundance (#organisms/m2)	290	190	10227

Composition

A second metric for the analysis of benthic community structure is the percent contribution of major taxa. Results are shown on Table 8-9. Oligochaetes were the most abundant organisms in the grab samples at all stations with the exception of stations 8, 11, and 12. A total of three and one bivalve (genera Asiatic clam and Zebra mussel) were found at sampling stations 11 and 12 respectively. Thus these sampling stations had the lowest abundance of organisms. Sediments from sampling stations 11 and 12 generally had the highest concentrations of metals and organic contaminants (PAHs) in the vessel slips. This indicates that the level of contamination at these sampling stations is potentially affecting even the relatively pollution-tolerant oligochaeta. Sampling station 8 was evenly divided between Oligochaeta and Bivalve. However, this sampling station had a depauterate community as there were only 2 organisms (1 Oligochaete and 1 Bivalvia) collected. Given the small sample sizes, results from the percent contribution of taxa are intended to be guidelines to build a conceptual model of benthic community structure at the site.

Functional Feeding Groups

The trophic-functional status and pollution tolerance scores of organisms detected in the vessel slips are shown on Table 8-10.

Table 8-10
Aquatic macroinvertebrates collected at sampling stations between December 1993 and February 1994.

Taxa	Functional Status	Pollution Tolerance
Annelida Oligochaeta	Collector	Tolerant
Insecta Dipteria	Collector	Tolerant
Mollusca Pelecypoda	Filterer	Intermediate
Tylenchus sp		

Regression analysis was carried out to compare benthic invertebrate abundance with chemical data at each sampling station. Correlation analysis is used to indicate relationships between benthic communities and concentration of a single contaminant at a sampling station. Correlation analyses could only be carried out using data on aquatic worms (Oligochaeta) due to the small sample size for the remaining organisms found at the vessel slips. Results from regression analysis are shown in Appendix F. Negative correlation was found for the majority of COCs, indicating a decrease in number of benthic organisms with an increase in concentrations of the chemicals. Chemicals with the highest correlation are shown on Table 8-11. There were relatively low correlations observed between number of aquatic worms and chemical concentrations (majority of chemicals had r^2 values below the 0.5 significance level). This may be in part due to the fact that a linear relationship is assumed in the model. It is possible that a threshold effect exists where adverse effects are only observed above a specific concentration. There is also a limited spread in the concentration range. As an example, there is a difference of only 20 ppm between the maximum and minimum concentrations of Arsenic. A larger spread in the concentration range is necessary to obtain any meaningful results from this analysis.

Table 8-11
Chemicals with highest correlations between abundance and concentrations

Chemical	r^2 Correlation
PCB Aroclor 1242	-0.62
PCB Aroclor 1254	-0.50
Lead	-0.53

In addition to the correlation analyses, contaminants of concern were screened against Ontario Sediment Quality Guidelines set forth by the Canadian Ministry of the Environment (MOE, 1993). These guidelines establish three levels of effect - No Effect Level (NEL), Lowest Effect Level (LEL) and Severe Effect Level (SEL) (MOE 1993). The NEL is the level at which the contaminant in the sediments does not affect fish or benthic organisms. The LEL represents the level of contamination at which there is no effect on the majority of benthic organisms. At concentrations above the SELs, the sediments are considered to be heavily polluted and likely to adversely affect benthic organisms. Comparison of sediment chemistry data against Ontario Sediment Quality Guidelines is shown in Appendix F. The SEL was given as µg/g organic carbon. The SEL was therefore converted to bulk sediment values by multiplying by the actual TOC (Total Organic Carbon) concentration of the sediments (MOE, 1993). This was done for each sampling section of the vessel slip. A sample calculation is shown in Appendix F.

The North Slip has 6 metals (arsenic, chromium, copper, lead, nickel, and zinc) well above the SEL guidance values. This indicates that the high concentrations of these contaminants have a high potential to adversely affect benthic community in the North Vessel Slip. The South Slip also showed contaminant concentrations well above the SEL guidance levels. The East End of the South Vessel Slip contained the highest number of contaminants above SEL guidance values. A total of 9 PAHs and 7 metals were found to be above SEL guidance values. The East End of the South Vessel Slip (composed of sampling stations 11 and 12) was also found to have the lowest total abundance of organisms (a total of 4 organisms found between the two sampling stations). We can therefore conclude that the high concentration of these contaminants is adversely affecting the benthic community at this section of the South Vessel Slip. The West End of the South Slip had 4 PAHs and 5 metals above SEL guidance values. No comparisons of metal concentrations from the middle section of the South Slip could be carried out as the data for these sampling stations (7 and 8) were missing from the original USFWS 1994 report.

Of significant importance is the fact that the metals found to be above SEL guidance values were also found in fish tissue samples. Because benthic organisms represent a significant source of exposure to the fish (since benthic organisms are an integral part of the food web), the metals are potentially bioaccumulating in benthic organisms and in turn, through trophic transfer, bioaccumulating in fish tissue.

It is recommended that measurements of concentrations of COCs in macroinvertebrate tissue be carried out. The results could be used to perform bioaccumulation models to determine the likelihood of contaminant transfer through the food chain.

9.0 Risk Characterization

Characterization of sediment quality

WSW sediment metal and PCB concentrations were initially screened against Illinois background concentrations. Eight metals and seven PCB Aroclors were found to be above extreme background concentrations. Sediment-derived chemicals were also compared against screening values. These represent values above which an ecotoxicological assessment indicates a potential threat to aquatic life (NSQS, 1998). Eighteen PAHs, six metals and 3 pesticides were above screening concentrations. Concentrations of COCs were sometimes as much as thirty times greater than screening values. Thus sediment in the vessel slips can be characterized as being potentially harmful to aquatic life, indicating an overall poor sediment quality in the vessel slips.

Characterization of toxicity test

Toxicity tests provide a direct measure of the effects of contaminated sediments on aquatic organisms. During the first round of sampling done by the USFWS, sampling stations showed no significant toxicity. Station numbers 1b, 3b, and 5b were excluded from the analysis due to inadequate control % mortalities (above the 10% limit required by the EPA). During the second round of sampling, sampling stations 5 and 6 (West End South Vessel Slip) were found to be acutely toxic to fish with mortalities ranging in the range of 35 to 65%. Strong correlation was found between 48-hr % mortalities and 48-hr un-ionized ammonia (r^2=0.86), and naphthalene concentrations (r^2=0.82). Correlation analyses were also carried out using data from the 48-96 hour mark. Results showed correlations between 48-96-hr % mortalities and naphthalene (r^2=0.61), un-ionized ammonia (r^2=0.50) and fluorene concentrations (r^2=0.50). Thus the chemicals with the strongest correlation during the first two days of the toxicity test were un-ionized ammonia, naphthalene, and fluorene (although not as strong as the two previous ones). It is likely that the high un-ionized ammonia concentration in the 48-hr mark is masking the toxicity effects of other chemicals in the bioassay water. Sampling station 12 (East Side South Slip) was not analyzed for toxicity. Concentrations of COCs in this sampling station were the highest of both vessel slips thus it is recommended that sediments from sampling station 12 be analyzed for toxicity to aquatic organisms. Overall, sampling stations 5 and 6 were found to be acutely toxic to the Fathead minnow while the remaining stations analyzed demonstrated no significant toxicity.

Characterization of tissue data

Tissue residue concentrations link exposure to the source of contamination. They provide a direct measure of the bioavailability of the contaminants in the vessel slips to aquatic organisms. Tissue residue analyses carried out by the USFWS show that PCB 1248, and heavy metals are readily available to higher trophic organisms such as fish. Two additional PAHs are readily bioavailable to fish in the South Vessel Slip. Measured concentrations of PCBs, copper and zinc in fish tissue were above their respective Tissue Screening Concentrations (NSBC, 1996). Thus these chemicals are at concentrations which could result in adverse toxicological effects for the fish.

Characterization of benthic community structure

Several contaminants of concern were found to be above Ontario Severe Effects Levels (SELs). At concentrations above SEL values, the sediments are considered to be heavily contaminated and likely to adversely affect benthic organisms (MOE, 1993). Thus contaminants with a potential to have a negative impact on the benthic community are shown in Table 9-1. Metals found to be above SEL guidance values were also found in fish tissue samples. Thus these chemicals could be potentially bioaccumulating in the food chain since benthic organisms represent an integral part of the food web.

Qualitative metrics used to analyze results of macroinvertebrate community structure showed a scarce benthic community in the order of 2 to 3% of organisms collected at the reference area (Calumet River). All species found in the vessel slips were pollution tolerant with the exception of the order mollusca, which were mostly found dead (see Table 8-7) and are introduced species. The community was dominated by Oligochaete or Aquatic worms, which are known to be tolerant to organic enrichment and metal contamination (USEPA, 1993). The East End of the South Vessel Slip had the lowest abundance of organisms. This section was also found to contain the highest concentrations of sediment-derived PAHs and metals, indicating that the level of contamination at this section of the vessel slip potentially acutely toxic to benthic organisms, including the relatively pollution tolerant Aquatic worms. A scarce benthic community with pollution tolerant organisms as the dominant species indicates a habitat that is potentially polluted and affecting sensitive species as well as the general population of macroinvertebrate organisms. It is recommended to measure COC concentrations in macroinvertebrate tissue. The results could be used to perform bioaccumulation models to determine the likelihood of contaminant transfer through the food chain.

Table 9-1
Chemicals above Ontario Severe Effects Levels (SELs)

North Slip	South Slip		
Metals	**PAHs**	**Metals**	**PCBs**
Arsenic	Fluorene	Cadmium	Aroclor 1254
Chromium	Phenanthrene	Chromium	Aroclor 1260
Copper	Anthracene	Copper	Aroclor 1016
Lead	Fluoranthene	Lead	Aroclor 1221
Nickel	Pyrene	Nickel	Aroclor 1232
Zinc	Chrysene	Zinc	
	Benzo(a)anthracene	Arsenic	
	Dibenzo(a,h)anthracene		
	Benzo(g,h,)perylene		

Limitations

Those chemicals below detection limits were assumed to have concentrations of half of the given detection limit. Several chemicals such as PCB Aroclor 1016, 1221, and 1231 or Pesticides (4,4'-DDT and 4,4'-DDE) were assumed to be half of their detection limits. They were thus determined to be COCs on the basis that half of their detection limits were above screening concentrations. This highlights the need for more stringent detection limits as the reported ones were often much greater than screening concentrations.

Recommendations

Based on the information presented, dredging of the vessel slips is recommended. Sediment chemistry data indicated an overall poor sediment quality in the vessel slips. Concentrations of COCs were sometimes as much as thirty times greater than screening concentrations. The West End of the South Vessel Slip was found to be acutely toxic to fish with mortalities in the range of 35 to 65%. Measured concentrations of three chemicals in tissue residue analyses were above Tissue Screening Concentrations, indicating a potential for adverse toxicological effects in the fish. In addition, the macroinvertebrate community was characterized as being scarce and dominated by pollution tolerant organisms. The habitat of the vessel slips was therefore determined to be polluted and adversely affecting sensitive macroinvertebrate organisms.

As discussed previously, conditions in the vessel slips have the potential to adversely affect fish communities as well as macroinvertebrate organisms. The following recommendations are made for possible future ecological studies:

- Lower detection limits to be able to discard with a greater degree of accuracy chemicals as Contaminant of Concern. This would diminish the uncertainty factor in the COC selection process.
- Measurement of metal concentrations in sediments from the middle section of the South Slip. This data was missing from the original USFWS Ecological Study and Impact Assessment report.
- Measurement of COC concentrations in macroinvertebrate tissue to then carry out bioaccumulation models. Results could be used to determine the likelihood of contaminant transfer through the food chain.
- Metal speciation calculations to determine the concentrations of metals in the water given their known concentrations in the sediments. These calculations would then be used to analyze results from the toxicity tests. This would include determination of the correlation between mortality of fish and concentrations of metals in the bioassay water.

- Toxicity testing using sediment from sampling station 12 (East End of South Slip). This sampling station contained the highest concentrations of COCs and is therefore likely to exhibit mortality greater than that of sampling stations 5 and 6 (East End of South Slip).
- A complete list of Tissue Screening Concentrations to be able to quickly assess toxicity potential of chemicals in fish tissue concentrations.

10.0 Human Health Risk Assessment

10.1 Exposure Pathways

Overview

In this section, the magnitude, frequency, duration, and route of direct and indirect exposure of receptor populations to contaminants of concern from the vessel slips will be determined. The receptor population represents the residents of the South Deering Community as well as recreational visitors. Exposure to these contaminants of concern can potentially occur via three pathways: dermal contact, ingestion, and inhalation. The ingestion pathway often results in higher risk estimates because of the greater absorption of chemicals through the stomach when compared to the adsorption of chemicals through the skin.

Exposure Pathways

The potential pathways by which people may be exposed to contaminants from the vessel slips are listed in Table 10-1. These were then examined and determined to be either complete or incomplete according to the following guidelines: 1) an origin and mechanism of chemical release, 2) a transport media by which the chemical is transferred between media, 3) a point of contact between the chemical and the receptor and 4) a route of exposure by which contact occurs (USEPA, 1993). If one of these conditions is not met then the exposure pathway is deemed incomplete.

Complete Exposure Pathways

In the case of the WSW vessel slips, two exposure pathways were determined to be complete: ingestion of contaminated fish, and dermal contact with surface water during fishing activities. Although the pathway from the inhalation of airborne contaminants is complete, it would be difficult to separate airborne contaminants originating from the river to those originating from nearby industrial activity and background sources. As a result, the air pathway was not considered in this risk assessment.

Table 10-1
Potential Exposure Pathways

INGESTION OF CONTAMINATED:

- Surface water
- Sediments
- Fish
- Drinking water

DERMAL CONTACT:

- Surface water
- Sediments

INHALATION OF AIRBORNE CONTAMINANTS

10.2 Data Source

Data Used in the Exposure Assessment

Sources of Data Reports

Surface Water Data

The surface water samples taken by the IEPA were analyzed for metals, volatile organic compounds, semi-volatile organic compounds, pesticides and PCBs (see Appendix E). These results were used in the calculations of the risk associated with dermal exposure to surface water during fishing activities. It is worth noting that although the sediment samples taken from the vessel slips showed considerable PAH contamination, the surface water samples were not analyzed for PAHs. Thus risk associated with the potential presence of PAHs in the surface water was not calculated due to the lack of data. Fish were collected from the North and South Vessel Slip.

Fish Data

A composite of three fish tissue samples (Common carp (*Cyprinus carpio*) from the North Slip and White perch (*Morone americana*) from each of the vessel slips) were analyzed for chemicals. The contamination levels in the fish are given in Table 7-4. These results were used to estimate the risk associated with consumption of fish from the vessel slip (resulting from fishing activities).

10.3 Exposure Assessment

10.3.1 Intakes: Ingestion of Contaminated Fish

The Calumet River is classified as a "general use water" thus it is possible for people to fish in the surrounding areas of WSW vessel slips. The USFWS report cites a person fishing along the shoreline of the Calumet River just upstream of WSW property fence. The equation used to estimate chemical intakes of contaminants due to ingestion of contaminated fish is shown in Table 10-2. The parameter values used to calculate chemical intakes are given in Table 10-3. These values were obtained from recommended values in the Exposure Factors Handbook (August 1996) and in the National Sediment Quality Survey (1998).

For each exposure scenario (average and reasonable maximum), different consumption patterns of fish were assumed to take place. The ingestion rate represents the estimated value of total fish consumed per day. This value is then multiplied by the fraction of fish consumed from the contaminated source (or FI factor) to give us an overall intake rate for fish originating from the vessel slips (IR * FI). The ingestion rate (g/day) of fish was converted to meals per year using the equation shown in Table 10-4. The numbers of meals of Calumet River fish consumed per year were 2 (for average consumption) and 33 (for reasonable maximum consumption).

Table 10-2
Equation used to calculate Chronic Daily Intake due to the ingestion of contaminated fish

$$CDI = \frac{EPC * IR * FI * EF * ED}{BW * AT}$$

CDI	Chronic Daily Intake (mg/kg-day)	
IR	Ingestion Rate (kg/day)	amount of fish consumed
FI	Fraction of fish Ingested from Contaminated Sources (unitless)	
EF	Exposure Frequency (days/year)	the number of days per year during which exposure occurs
ED	Exposure Duration (year)	the number of years during which exposure occurs
BW	Body Weight (kg)	average body weight over the exposure period
AT	Averaging Time (days)	period over which exposure is averaged

Table 10-3
Parameters used to estimate contaminant intakes resulting from the consumption of contaminated fish from the Vessel Slips

Variable	Units	Value Used	Comment
IR	Kg/day	0.0065	Average: National Sediment Quality Survey (1998)
		0.025	Maximum: Exposure Factors Handbook (1996)
FI	-	0.1	Average: values representative of nearshore Lake Michigan fish (USEPA, 1994b)
		0.25	Maximum: values representative of nearshore Lake Michigan fish (USEPA, 1994b)
EF	Days/year	350	USEPA (1991a)
ED	years	9	Average: USEPA (1989a)
		30	Maximum: USEPA (1989a)
BW	Kg	70	50th percentile average for adult men and women (USEPA, 1989b)
AT	days	3285	Average: 9yrs * 365 days/yr (noncarcinogenic risk) (USEPA, 1994b)
		10950	Maximum: 30yrs * 365 days/yr (noncarcinogenic risk) (USEPA, 1994b))
		25550	70yrs * 365 days/yr (carcinogenic risk)

Table 10-4
Equation used to convert ingestion rate in g/day to meals per year (USEPA, 1993).

$$IR\left(\frac{\text{meals}}{\text{year}}\right) = IR\left(\frac{g}{\text{day}}\right) * FI * \left(\frac{1\ \text{meal}}{150\ g}\right) * \left(\frac{365\ \text{days}}{\text{year}}\right)$$

IR	Ingestion Rate (meals/year)	amount of meals of fish consumed per year
IR	Ingestion Rate (g/day)	amount of grams of fish consumed per year
FI	Fraction of fish Ingested from contaminated Sources (unitless)	

10.3.2 Intakes: Dermal contact with surface water (during fishing activities)

Dermal contact with surface water may occur during fishing activities. The equation used to estimate chemical intakes due to dermal exposure is shown in Table 10-5. The parameter values used to calculate the intake estimates are shown in Table 10-6. The intake rates vary with the surface area exposed and with the permeability of individual chemicals through the skin (USEPA, 1994b). The permeability is characterized by the chemical's Permeability Constant (PC). Appendix I shows the PCs for the site's contaminants of concern. The parameter variables were obtained from recommended values (USEPA, 1994b). Under the average exposure scenario, the body surface area exposed to the water covers the hands and feet. Under the reasonable maximum scenario, exposed surface area includes the hands, feet, forearms, and lower legs.

Table 10-5
Equation used to calculate absorbed dose due to dermal exposure to surface water

$$AD = \frac{ED}{70\ yrs} \left[\frac{CW * SA * PC * ET * EF * ED * CF}{BW * AT} \right]$$

AD	Absorbed Dose (mg/kg-day)
CW	Chemical Concentration in Water (mg/L)
SA	Surface Area of skin exposed to contaminants (cm^2)
PC	Chemical specific Permeability Constant (cm/hour)
ET	Exposure Time (hours/day)
ED	Exposure Duration (year)
CF	Conversion Factor (1L/1000 cm^3)
BW	Body Weight (kg)
AT	Averaging Time (days)

Table 10-6
Parameters used to estimate absorbed doses due to dermal exposure to chemicals in surface water of the vessel slips.

Variable	Units	Value Used	Comment
CF	L/cm^3	10^{-3}	
SA	cm2	1740	Average: SA of hands and feet (USEPA, 1994b)
		4820	Maximum: SA of hands, forearms, lower legs, and feet (USEPA, 1994b)
EF	Days/year	40	Average: USEPA, 1994b
		60	Maximum: USEPA, 1994b
ED	years	9	Average: USEPA, 1994b
		30	Maximum: USEPA, 1994b
BW	Kg	70	50^{th} percentile average for adult men and women (USEPA, 1989b)
AT	days	3285	Average: 9yrs * 365 days/yr (noncarcinogenic risk) (USEPA, 1994b)
		10950	Maximum: 30yrs * 365 days/yr (noncarcinogenic risk) (USEPA, 1994b)

10.4 Toxicity Analysis

Toxicity values

Two types of toxicity values were used to calculate the noncarcinogenic and carcinogenic risk. The Reference Dose (RfD) provides an estimate of the daily contaminant exposure that is not likely to cause harmful effects during either a portion of a person's life or his/her entire lifetime (USEPA, 1994b). The RfD value is used to estimate noncarcinogenic effects associated with the contaminants of concern at the site. The slope factor (SF) is used in risk assessment to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1994b). This toxicity value is used to estimate carcinogenic risk associated with the contaminants of concern at the site. Each contaminant is also given a weight-of-evidence rank to indicate the strength of evidence that the contaminant is a human carcinogen (Table 10-7). The toxicity values for the chemicals evaluated in this risk assessment are given in Tables 10-8 and 10-12. These values were obtained from the EPA's Integrated Risk Information System (IRIS) database. However, the risk assessment was limited by the lack of toxicity values for three contaminants found in fish tissue. These contaminants included PCB Aroclor 1248, Copper, and Lead. The particular valence state of chromium found in fish tissue was not specified in the USFWS report. Chromium VI is more toxic to aquatic organisms than Chromium III. In order to carry out a conservative risk assessment, Chromium VI was assumed to be the major valence state of chromium in the fish tissue.

Table 10-7
EPA weight-of-evidence classification system for carcinogenicity (IRIS Database)

Group	Description
A	Human Carcinogen
B1	Probable Human Carcinogen - limited human data available
B2	Probable human carcinogen - sufficient evidence in animals, inadequate evidence in humans
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of Noncarcinogenicity for Humans

10.5 Baseline Risk Characterization

This section provides the calculated potential human health risks associated with the exposure routes previously discussed. Two methods of expressing carcinogenic and noncarcinogenic risks of adverse effects are presented. First, the chemical-specific risks (HQs) were calculated using chemical-specific Reference Doses. Second, the sum of the chemical-specific risks was calculated to estimate a cumulative pathway-specific risk (HI). It is assumed that there are no synergistic or antagonistic interactions between chemicals.

Noncarcinogenic effects were calculated by comparing an exposure level over a specified time period with a reference dose (RfD) derived from a similar exposure period [otherwise known as a hazard quotient (HQ)] (USEPA, 1994b). The Hazard Quotient (HQ) is the ratio of estimated intake dose from exposure to the reference dose for the particular contaminant. Thus HQ = intake dose/RfD. The reference dose (RfD) represents a specific dose below which the contaminant fails to induce any adverse health effects in the exposed populations. RfDs are dependent on the route of exposure. The RfDs associated with intake were chosen for this risk assessment. To account for an exposure to multiple contaminants, all HQs are summed up to provide a final measure of the risk from a consortium of contaminants. This sum is represented by the Hazard Index

(HI). A HI value of less than 1 indicates that exposures are not likely to incur adverse noncarcinogenic effects on the population. HI values greater than 1 may be of concern particularly when additional significant risk factors are present (e.g. other contaminants at levels of concern) (USEPA, 1989a). Thus the higher the HQ, the more likely that an adverse effect will occur as a result of exposure to the chemical (National Sediment Quality Survey). This assumption of additivity however, does not account for any synergistic or antagonistic effects that may occur among chemicals.

Carcinogenic risk represents the probability of an individual developing cancer over a lifetime as a result of exposure to a chemical concentration for a specified period of time. This risk is calculated using chronic daily intakes multiplied by the oral slope factor (USEPA, 1994b). The oral slope factor (SF) is used to convert estimated daily intakes averaged over a lifetime to incremental risk of an individual. The estimated upper-bound excess lifetime cancer risk is 10^{-5} (1 in 100,000 extra chance of cancer over a lifetime) whereas the lower-bound is 10^{-6} (1 in 1,000,000 extra chance of cancer over a lifetime) (USEPA, 1994b). Risks higher than 10^{-6} exceeds the lower-bound EPA guidelines and would therefore represent a non-acceptable excess cancer risk.

Fish Consumption Risk Estimates

None of the contaminants found in fish tissue were classified as carcinogens and thus none were assigned slope factors in the EPA's IRIS database. As a result, the carcinogenic risk estimates were not calculated. Shown in Table 10-8, is a summary of the EPA weight-of-evidence classification for carcinogenicity of each contaminant evaluated for the ingestion of contaminated fish.

Table 10-8
EPA weight-of-evidence classification for noncarcinogenicity of COCs (IRIS, current as of 6/4/2000)

Chemical	Classification	R_fD	SF
PCB Aroclor 1248	NA	NA	NA
Fluoranthene	D	4.00E-02	NA
Pyrene	NA	3.00E-02	NA
Copper	D	NA	NA
Lead	B2	NA	NA
Nickel	NA	2.00E-02	NA
Selenium	D	5.00E-03	NA
Zinc	D	3.00E-01	NA

Separate risk estimates were carried out for three species of fish collected by the USFWS from the vessel slips. Results are shown in Tables 10-9 through 10-11. Noncarcinogenic risk estimates were not significant for the consumption of White perch (Tables 10-9 and 10-10) or Common carp (Table 10-11). Noncarcinogenic risks posed by individual contaminants as well as for the combinations of contaminants (represented by HQ and HI respectively) were far below levels of concern (i.e., all HQs<1 and HIs<1). The reasonable maximum HI for consumption of North Slip White perch (Table 10-10) was 0.648. This value is close to a HI of 1. In addition, there are three missing contribution of risk associated with PCB Aroclor 1248, copper, and lead. The HQs for these three chemicals could not be calculated due to a lack of R_fD values. Thus if the contribution from these contaminants were to be accounted for, the HI for the consumption of North Slip White perch might have been bumped up to 1 and above.

Table 10-9
Noncarcinogenic risk associated with consumption of whole White perch collected from WSW South Vessel Slip

Chemical	Fish Concentration (mg/kg)	Noncarcinogenic Intake (mg/kg/day)		Hazard Quotient (Intake/R_fD)	
		Average	Maximum	Average	Maximum
PCBs					
Arochlor 1248	0.9	8.01E-05	6.7E-04	-	-
Organics					
Fluoranthene	0.046	4.1E-06	3.4E-05	1.02E-05	2.1E-04
Pyrene	0.038	3.4E-06	2.81E-05	1.1E-05	2.3E-04
Metals					
Copper	23.5	2.09E-03	1.7E-02	-	-
Lead	2.7	2.4E-04	2.0E-03	-	-
Nickel	4.8	4.3E-04	3.6E-03	2.1E-03	4.4E-02
Selenium	2.4	2.1E-04	1.8E-03	4.3E-03	8.9E-02
Zinc	110	9.8E-03	8.14E-02	3.3E-03	6.8E-02
HAZARD INDEX				0.0097	0.201

Table 10-10
Noncarcinogenic risk associated with consumption of whole White perch collected from WSW North Vessel Slip

Chemical	Fish Concentration (mg/kg)	Noncarcinogenic Intake (mg/kg/day)		Hazard Quotient (Intake/R_fD)	
		Average	Maximum	Average	Maximum
PCBs					
Arochlor 1248	0.57	5.07E-05	4.2E-04	-	-
Metals					
Chromium VI	8.3	7.4E-04	6.12E-03	2.5E-02	5.12E-01
Copper	6.4	5.7E-04	4.7E-03	-	-
Lead	2.2	2.0E-04	1.6E-03	-	-
Nickel	4.7	4.2E-04	3.5E-03	2.1E-03	4.4E-02
Zinc	150	1.3E-02	1.1E-01	4.5E-03	9.3E-02
HAZARD INDEX				0.0312	0.648

Table 10-11
Noncarcinogenic risk associated with consumption of wh Common carp collected from WSW South Vessel Slip

Chemical	Fish Concentration (mg/kg)	Noncarcinogenic Intake (mg/kg/day) Average	Noncarcinogenic Intake (mg/kg/day) Maximum	Hazard Quotient (Intake/R_fD) Average	Hazard Quotient (Intake/R_fD) Maximum
PCBs					
Arochlor 1248	1	8.9E-05	7.4E-04	-	-
Metals					
Chromium IV	2	1.8E-04	1.5E-03	5.94E-03	1.23E-01
Copper	8.9	7.9E-04	6.6E-03	-	-
Lead	0.64	5.7E-5	4.7E-04	-	-
Nickel	5.2	4.6E-04	3.8E-03	2.3E-03	4.8E-02
Zinc	131	1.2E-02	9.7E-02	3.9E-03	8.1E-02
HAZARD INDEX				0.0121	0.252

Dermal Exposure to Surface Water

Only one surface water contaminant (Arsenic) was classified as a human carcinogen. The remaining contaminants were classified as noncarcinogens and thus none were assigned slope factors in the EPA's IRIS database. As a result, carcinogenic risk estimates were calculated for Arsenic only. Shown in Table 10-12 is a summary of the weight-of-evidence classification of contaminants associated with surface water exposure.

Table 10-12
EPA weight-of-evidence classification for carcinogenicity of COCs (IRIS, current as of 6/4/2000)

Chemical	Carcinogenic Weight of Evidence Class	R_fD mg/kg/day	Oral SF mg/kg/day
Chloroform	B2	NA	NA
Copper	D	NA	NA
Lead	B2	NA	NA
Nickel	NA	2.00E-02	NA
Selenium	D	5.00E-03	NA
Zinc	D	3.00E-01	NA
Chromium VI	D	NA	NA
Aluminium	NA	4.00E-04	NA
Arsenic	A	3.00E-04	1.5E+0
Barium	D	7.00E-02	NA
Cadmium	B1	5.00E-04	NA
Calcium	NA	4.00E-02	NA
Iron	NA	NA	NA
Magnesium	NA	NA	NA
Manganese	D	1.40E-01	NA
Potassium	NA	5.00E-02	NA
Sodium	NA	4.00E-02	NA

NA – Not Available (not classified in the IRIS Database)

Results of lifetime cancer risks from Arsenic contamination of surface water are shown in Table 10-13.

Table 10-13
Carcinogenic Risks associated with dermal exposure to surface water in the WSW vessel slips

Chemical	Surface Water Concentration (IEPA, 1996) (mg/L)	Adsorbed Dose (mg/kg/day)		Carcinogenic Risk (Adsorbed Dose * SF)	
		Average	Maximum	Average	Maximum
NORTH SLIP					
Arsenic	0.0012	7.47E-08	1.032E-06	1.99E-10	2.76E-09
SOUTH SLIP					
Arsenic	0.0018	1.7E-07	2.3E-06	2.99E-10	4.14E-09

Results of carcinogenic risk estimates showed levels below the level of concern (i.e., $<10^{-6}$) for the average and reasonable exposure scenarios.

Results of noncarcinogenic HI calculations for the North and South Vessel Slip are shown in Tables 10-14 and 10-15 respectively. Noncarcinogenic risks for dermal exposure to surface water were far below levels of concern (i.e., HI<1).

Table 10-14
Noncarcinogenic risk associated with dermal exposure to surface water in the WSW North Slip.

Chemical	Surface Water Concentration (mg/L)	Adsorbed Dose (mg/kg/day)		Hazard Quotient (Intake/R_fD)	
		Average	Maximum	Average	Maximum
Chloroform	3	-	-	-	-
Aluminium	283	-	-	-	-
Arsenic	0.675	7.5E-08	1.04E-06	2.5E-04	3.5E-03
Barium	25.5	2.8E-06	3.9E-05	4.03E-05	5.58E-04
Cadmium	2.58	-	-	-	-
Calcium	41000	-	-	-	-
Copper	4.63	5.1E-07	7.1E-06	-	-
Iron	320	-	-	-	-
Lead	5.8	-	-	-	-
Magnesium	9900	-	-	-	-
Manganese	34.5	3.8E-06	5.3E-06	2.7E-05	3.8E-04
Nickel	14.05	1.6E-06	2.2E-05	7.8E-05	1.08E-03
Potassium	2927.5	-	-	-	-
Sodium	37875	-	-	-	-
Zinc	9.53	1.05E-06	1.5E-05	3.5E-06	4.9E-05
HAZARD INDEX				3.98E-04	5.51E-03

Table 10-15
Noncarcinogenic risk associated with dermal exposure to surface water in the WSW South Vessel Slip.

Chemical	Surface Water Concentration (mg/L)	Adsorbed Dose (mg/kg/day)		Hazard Quotient (Intake/R_fD)	
		Average	Maximum	Average	Maximum
Chloroform	3	-	-	-	-
Benzene	8	-	-	-	-
Toluene	5	-	-	-	-
Aluminium	614	-	-	-	-
Arsenic	1.5	1.7E-07	2.3E-06	0.00055	0.0077
Barium	27.45	3.04E-06	4.2E-05	4.34E-05	0.0006
Calcium	40150	-	-	-	-
Iron	622	-	-	-	-
Lead	4.05	-	-	-	-
Magnesium	11950	-	-	-	-
Manganese	48.55	5.37E-06	7.44E-05	3.84E-05	0.00053
Nickel	7	7.75E-07	1.07E-05	3.87E-05	0.00054
Potassium	2585		-	-	-
Sodium	37200		-	-	-
Zinc	14.15	1.57E-06	2.17E-05	5.22E-06	7.23E-05
HAZARD INDEX				0.00068	0.0094

10.6 Risk Characterization

The risk characterization step combines the exposure pathway findings with the toxicity estimates to quantitatively describe the human health risk posed by contaminants in the vessel slips.

This assessment focused on two pathways by which residents of the South Deering Community could be exposed to the contaminants found in the sediments:

consumption of contaminated fish from the vessel slips and dermal exposure to contaminated surface water while fishing. Other exposure pathways were determined to be incomplete (e.g. ingestion of sediments).

Ingestion of Contaminated Fish

Carcinogenic Risk

None of the contaminants found in fish tissue samples were classified as human carcinogens. As a result, the carcinogenic risk estimates were not calculated (since they pose noncarcinogenic risk).

Noncarcinogenic Risk

Noncarcinogenic risk estimates were insignificant for the consumption of White perch or Common carp. It should be noted however, that the reasonable maximum HI for the consumption of North Slip White perch (Table 10-10) was 0.648. This value is close to levels of concern (i.e., HI=1). In addition, there were three chemicals not accounted for in the calculations (PCB Aroclor 1248, copper, and lead). These contaminants were not accounted for because their R_fD values were not available from the IRIS Database. Thus if the contributions from these contaminants were to be counted for, the HI for the consumption of White perch from the North Slip could be bumped up to 1 and above.

Dermal Exposure to Surface Waters

Carcinogenic Risks

Carcinogenic risks were only calculated for Arsenic since it was the only carcinogen found in the surface water. Carcinogenic risks from dermal exposure were insignificant. All carcinogenic risks were below levels of concern (i.e., $<10^{-6}$).

Noncarcinogenic Risk

Noncarcinogenic risks from dermal exposure to surface water were far below levels of concern (i.e., all HQs<1). Cumulative noncarcinogenic effects were also below a level of concern (i.e., all HIs<1) for both typical and reasonable maximum exposure scenarios.

Based on these very low risk estimates, noncarcinogenic and carcinogenic risks to anglers exposed to vessel slip surface waters were insignificant. Similarly, Noncarcinogenic risk estimates were insignificant for the consumption of White perch or Common carp.

APPENDIX D

USFWS Wet Weight Sediment Data
IEPA Wet Weight Sediment Data
USFWS vs. IEPA Wet Weight Sediment Concentrations
Vessel Slip Dry Weight Concentrations
Sediment Chemistry Screening Values
Methodology for conversion of wet weight to dry weight concentrations
IEPA classification of Illinois Stream Sediments

USFWS North Slip - Bulk Sediment

	West End			Middle Section			East Section		
	WSW-1A+B	WSW-2A+B	Average	WSW-3A+B	WSW-4A+B	Average	WSW-9A+B	WSW-10A+B	Average
Moisture Content (%	60	60	60	57	50	53.5	46	50	48
TOC	0.0381	0.0353	0.0367	0.0389	0.0457	0.0423	0.0497	0.0495	0.0496
Compound									
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	890	1000	945	540	390	465	930	940	935
Acenapthylene	<660	370	350	220	220	220	47	370	208.5
Acenaphthene	<660	<620	<660	<58	<500	<500	<460	<500	<500
Fluorene	240	270	255	160	120	140	260	340	300
Phenanthrene	860	1100	980	610	460	535	1100	1400	1250
Anthracene	350	410	380	230	190	210	420	550	485
Fluoranthane	1100	<620	705	<58	<500	<500	1300	1700	1500
Pyrene	2300	<620	1305	<58	<500	<500	2700	3200	2950
Chrysene	1300	1700	1500	<58	690	690	1700	2100	1900
Benzo (a) anthracene	620	660	640	410	340	375	710	870	790
Benzo (b) fluoranthene	600	760	680	<19	340	340	650	770	710
Benzo (k) fluoranthene	390	200	295	<19	230	230	420	480	450
Benzo (a) pyrene	620	250	435	450	370	410	760	840	800
Dibenzo (a,h) anthracen	1400	990	1195	<35	<300	<300	980	910	945
Benzo (g,h,i) perylene	<920	<880	<920	<81	<700	<700	1400	1400	1400
Indno (1,2,3-cd) pyrene	670	780	725	420	410	415	760	770	765
Acetone	na	na	na	na	na	na	na	na	na
2-Butanone	na	na	na	na	na	na	na	na	na
4-Methylphenol	na	na	na	na	na	na	na	na	na
2-Methylnaphthalene	na	na	na	na	na	na	na	na	na
Dibenzofuran	na	na	na	na	na	na	na	na	na
Bis(2-ethylhexyl)phthalat	na	na	na	na	na	na	na	na	na
PCBs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Arochlor 1242	<1200	<1100	<1200	<1000	<880	<1000	760	1800	1280
Arochlor 1248	<2100	<2000	<2100	<1900	<1600	<1900	<1500	<1600	<1600
Arochlor 1254	460	310	385	160	260	210	<3000	<3200	<3200
Arochlor 1260	<4200	<4000	<4200	<3700	<3200	<3700	<3000	<3200	<3200
Arochlor 1016	<2100	<2000	<2100	<1900	<1600	<1900	<1500	<1600	<1600
Arochlor 1221	<2100	<2000	<2100	<1900	<1600	<1900	<1500	<1600	<1600
Arochlor 1232	<2100	<2000	<2100	<1900	<1600	<1900	<1500	<1600	<1600

USFWS North Slip - Bulk Sediment

	West End			Middle Section			East Section		
	WSW-1A+B	WSW-2A+B	Average	WSW-3A+B	WSW-4A+B	Average	WSW-9A+B	WSW-10A+B	Average
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Arsenic	19.3	14	16.65	17.9	19.9	18.9	15.6	15.1	15.35
Cadmium	4.2	3.1	3.65	3.8	3.4	3.6	2.7	2.8	2.75
Chromium	101	86.2	93.6	115	123	119	70.8	78.4	74.6
Copper	136	128	132	120	113	116.5	123	118	120.5
Iron	65400	62700	64050	69300	68100	68700	77200	86500	81850
Lead	310	290	300	266	241	253.5	247	250	248.5
Mercury	0.4	0.27	0.335	0.54	0.38	0.46	0.36	0.34	0.35
Nickel	63.4	61.7	62.55	52.8	58.9	55.85	50.3	54	52.15
Selenium	<1.3	<1.3	<1.3	<1.2	<1	<1.2	<1.1	<1	<1.1
Zinc	986	1020	1003	1050	823	936.5	986	962	974
Total Cyanide	1.9	1.7	1.8	3.1	3.7	3.4	1.8	2.3	2.05
Ammonia-N	na	na	na	na	na	na	na	na	na
Total Sulfate	na	na	na	na	na	na	na	na	na
VOCs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Benzene	<5.0	<5.0	<5.0	<4.7	<4.0	<4.7	<3.7	<4.0	<4.0
Toluene	<5.0	<5.0	<5.0	<4.7	<4.0	<4.7	<3.7	<4.0	<4.0
Ethylbenzene	<5.0	<5.0	<5.0	<4.7	<4.0	<4.7	<3.7	<4.0	<4.0
m-Xylene	<5.0	<5.0	<5.0	<4.7	<4.0	<4.7	<3.7	<4.0	<4.0
o-Xylene	<5.0	<5.0	<5.0	<4.7	<4.0	<4.7	<3.7	<4.0	<4.0
p-Xylene	<5.0	<5.0	<5.0	<4.7	<4.0	<4.7	<3.7	<4.0	<4.0

USFWS North Slip - Bulk Sediment

	West End			Middle Section			East Section		
	WSW-1A+B	WSW-2A+B	Average	WSW-3A+B	WSW-4A+B	Average	WSW-9A+B	WSW-10A+B	Average
Pesticides	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
alpha-BHC	<53	<50	<53	<47	<40	<47	<37	<40	<40
beta-BHC	<110	<100	<110	<93	<80	<93	<74	<80	<80
delta-BHC	<160	<150	<160	<140	<120	<140	<110	<120	<120
gamma-BHC (Lindane)	<71	<68	<71	<63	<54	<63	<50	<54	<54
Heptachlor	<53	<50	<53	<47	<40	<47	<37	<40	<40
Aldrin	<71	<68	<71	<63	<54	<63	<50	<54	<54
Heptachlor Epoxide	<1500	<1400	<1500	<1300	<1100	<1300	<1000	<1100	<1100
Endosulfan I	<250	<240	<250	<220	<190	<220	<170	<190	<190
Dieldrin	<34	<32	<34	<30	<26	<30	<24	<26	<26
4, 4'-DDE	<71	<68	<71	<63	<54	<63	<50	<54	<54
Endrin	<21	<20	<21	<19	<16	<19	<74	<80	<80
Endosulfan II	<71	<68	<71	<63	<54	<63	<50	<54	<54
4, 4'-DDD	<200	<190	<200	<170	<150	<170	<140	<150	<150
Endosulfan sulfate	<1200	<1100	<1200	<1000	<880	<1000	<810	<880	<880
4, 4'-DDT	<210	<200	<210	<190	<160	<190	<150	<160	<160
Methoxychlor	<3100	<3000	<3100	<2700	<2400	<2700	<2200	<2400	<2400
Endrin Ketone	<420	<400	<420	<370	<320	<370	na	na	na
Chlordane	<250	<240	<250	<220	<190	<220	<170	<190	<190
Toxaphene	<4300	<4100	<4300	<3800	<3300	<3800	<3000	<3200	<3200
Endrin Aldehyde	<390	<380	<390	<350	<300	<350	<280	<300	<300

USFWS South Slip - Bulk Sediment

	West End			Middle Section			East End		
	WSW-5A+B	WSW-6A+B	Average	WSW-7A+B	WSW-8A+B	Average	WSW-11A+B	WSW-12A+B	Average
Moisture Content (%)	52	52	52	54	54	54	55.1	54.7	54.9
TOC	0.0572	0.0553	0.05625	0.050825	0.050825	0.10165	0.046	0.0448	0.0454
Compound									
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	16000	11000	13500	3200	2600	2900	2500	3100	2800
Acenapthylene	5200	780	2990	<5400	<5400	<5400	630	2500	1565
Acenaphthene	<5200	<5200	<5200	<5400	<5400	<5400	<5300	<5200	<5300
Fluorene	2500	1800	2150	1100	950	1025	1600	18000	9800
Phenanthrene	11000	7400	9200	4700	4220	4460	11000	100000	55500
Anthracene	4300	3100	3700	2100	1800	1950	4400	40000	22200
Fluoranthane	27000	18000	22500	13000	13000	13000	29000	130000	79500
Pyrene	15000	9700	12350	7200	6900	7050	14000	60000	37000
Chrysene	11000	6800	8900	4400	4600	4500	10000	39000	24500
Benzo (a) anthracene	6200	4100	5150	2900	3000	2950	5900	24000	14950
Benzo (b) fluoranthene	6600	4400	5500	3000	3100	3050	5600	23000	14300
Benzo (k) fluoranthene	2900	1900	2400	1500	1500	1500	2500	9500	6000
Benzo (a) pyrene	6100	4200	5150	2800	3000	2900	5300	23000	14150
Dibenzo (a,h) anthracer	15000	9900	12450	7000	<3300	7000	11000	51000	31000
Benzo (g,h,i) perylene	8900	6100	7500	4100	3400	3750	6600	27000	16800
Indno (1,2,3-cd) pyrene	5800	3900	4850	2600	2600	2600	4600	19000	11800
Acetone	na	na	na	na	na	na	na	na	na
2-Butanone	na	na	na	na	na	na	na	na	na
4-Methylphenol	na	na	na	na	na	na	na	na	na
2-Methylnaphthalene	na	na	na	na	na	na	na	na	na
Dibenzofuran	na	na	na	na	na	na	na	na	na
Bis(2-ethylhexyl)phthalε	na	na	na	na	na	na	na	na	na
PCBs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Arochlor 1242	1200	1600	1400	3400	3600	3500	4000	3600	3800
Arochlor 1248	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700
Arochlor 1254	<3300	<3300	<3300	<3500	<3500	<3500	<3400	<3300	<3400
Arochlor 1260	<3300	<3300	<3300	<3500	<3500	<3500	<3400	<3300	<3400
Arochlor 1016	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700
Arochlor 1221	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700
Arochlor 1232	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700	<1700

USFWS South Slip - Bulk Sediment

	West End			Middle Section			East End		
	WSW-5A+B	WSW-6A+B	Average	WSW-7A+B	WSW-8A+B	Average	WSW-11A+B	WSW-12A+B	Average
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Arsenic	12.4	13.8	13.1	na	na	na	19	18.7	18.85
Cadmium	3.2	3.3	3.25	na	na	na	5.4	22.8	14.1
Chromium	69.6	77.3	73.45	na	na	na	110	78.7	94.35
Copper	102	114	108	na	na	na	143	118	130.5
Iron	47800	52800	50300	na	na	na	101000	74900	87950
Lead	229	249	239	na	na	na	765	487	626
Mercury	0.79	0.54	0.665	na	na	na	0.25	0.52	0.385
Nickel	43.7	47.3	45.5	na	na	na	66.5	56	61.25
Selenium	<1.1	<1	<1.1	na	na	na	<1.1	<1.1	<1.1
Zinc	942	1050	996	na	na	na	1990	1330	1660
Total Cyanide	2.5	2.1	2.3	na	na	na	3.6	2.8	3.2
Ammonia-N	na	na	na	na	na	na	na	na	na
Total Sulfate	na	na	na	na	na	na	na	na	na
VOCs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Benzene	4.7	3.6	4.15	<22	<4.3	<22	<4.3	<4.2	<4.3
Toluene	8.8	<4.2	8.8	920	6.3	463.15	<4.3	<4.2	<4.3
Ethylbenzene	<4.2	<4.2	<4.2	<22	<4.3	<22	<4.3	<4.2	<4.3
m-Xylene	11	5.1	8.05	<22	<4.3	<22	<4.3	<4.2	<4.3
o-Xylene	12	2.5	7.25	<22	<4.3	<22	<4.3	<4.2	<4.3
p-Xylene	12	2.5	7.25	<22	<4.3	<22	<4.3	<4.2	<4.3

USFWS South Slip - Bulk Sediment

	West End			Middle Section			East End		
	WSW-5A+B	WSW-6A+B	Average	WSW-7A+B	WSW-8A+B	Average	WSW-11A+B	WSW-12A+B	Average
Pesticides	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
alpha-BHC	<42	<42	<42	<43	<43	<43	<43	<42	<43
beta-BHC	<83	<83	<83	<87	<87	<87	<85	<83	<85
delta-BHC	<120	<120	<120	<130	<130	<130	<130	<120	<130
gamma-BHC (Lindane)	<56	<56	<56	<59	<59	<59	<57	<56	<57
Heptachlor	<42	<42	<42	<43	<43	<43	<43	<42	<43
Aldrin	<56	<56	<56	<59	<59	<59	<57	<56	<57
Heptachlor Epoxide	<1200	<1200	<1200	<1200	<1200	<1200	<1200	<1200	<1200
Endosulfan I	<200	<200	<200	<200	<200	<200	<200	<200	<200
Dieldrin	<27	<27	<27	<28	<28	<28	<28	<27	<28
4, 4'-DDE	<56	<56	<56	<59	<59	<59	<57	<56	<57
Endrin	<83	<83	<83	<87	<87	<87	<85	<83	<85
Endosulfan II	<56	<56	<56	<59	<59	<59	<57	<56	<57
4, 4'-DDD	<160	<160	<160	<160	<160	<160	<160	<160	<160
Endosulfan sulfate	<920	<920	<920	<960	<960	<960	<940	<920	<940
4, 4'-DDT	<170	<170	<170	<170	<170	<170	<170	<170	<170
Methoxychlor	<2500	<2500	<2500	<2600	<2600	<2600	<2500	<2500	<2500
Endrin Ketone	na	na	na	na	na	na	na	na	na
Chlordane	<200	<200	<200	<200	<200	<200	<200	<200	<200
Toxaphene	<3300	<3300	<3300	<3500	<3500	<3500	<3400	<3300	<3400
Endrin Aldehyde	<310	<310	<310	<330	<330	<330	<320	<310	<320

IEPA North Slip - Bulk Sediment

	West Section	Middle Section	East Section		
	X-202	X-203	X-204	X-205	Average
Moisture Content (%)	63	40	48	47	47.5
TOC	0.395	0.042867	0.042867	0.042867	0.042867
Compound					
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	1100	<2700	670	730	700
Acenapthylene	240	<2700	150	160	155
Acenaphthene	190	<2700	<630	130	130
Fluorene	410	<2700	<630	350	350
Phenanthrene	1500	4100	1100	1100	1100
Anthracene	480	1600	330	320	325
Fluoranthane	1200	12000	1000	1200	1100
Pyrene	1200	8400	1100	1800	1450
Chrysene	1500	6200	1200	1200	1200
Benzo (a) anthracene	1100	6200	860	850	855
Benzo (b) fluoranthene	990	4600	600	600	600
Benzo (k) fluoranthene	670	3700	550	<620	550
Benzo (a) pyrene	1000	4100	770	850	810
Dibenzo (a,h) anthracene	<890	<2700	<630	<620	<630
Benzo (g,h,i) perylene	<890	<2700	<630	<620	<630
Indno (1,2,3-cd) pyrene	<890	2200	<630	<620	<630
Acetone	280	80	140	78	109
2-Butanone	62	15	35	22	28.5
4-Methylphenol	2400	<2700	<630	<620	<630
2-Methylnaphthalene	630	<2700	340	340	340
Dibenzofuran	350	<2700	200	<210	200
Bis(2-ethylhexyl)phthalate	690	<2700	<630	<620	<630
PCBs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Arochlor 1242	480	<55	490	560	525
Arochlor 1248	<89	180	420	<61	420
Arochlor 1254	290	36	390	450	420
Arochlor 1260	150	78	150	170	160
Arochlor 1016	na	na	na	na	na
Arochlor 1221	na	na	na	na	na
Arochlor 1232	na	na	na	na	na
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Arsenic	5.9645	5.8296	6.3603	12.4701	9.4152
Cadmium	0.79	<0.59684	1.5471	1.182	1.36455
Chromium	25.991	14.713	42.29	31.2	36.745
Copper	51.35	28.59	46.3	47.75	47.025
Iron	24174	27621.2	44808.6	41842.8	43325.7
Lead	105.07	63.2928	104.286	92.196	98.241
Mercury	0.13825	0.21514	0.13752	0.18321	0.160365
Nickel	18.0515	13.12	26.76	23.4	25.08
Selenium	0.3002	0.22902	<0.9741	<0.9456	<0.9741
Zinc	309.285	174.888	352.968	309.684	331.326
Total Cyanide	<0.5135	1.1104	0.9168	0.50235	0.709575
Ammonia-N	na	na	na	na	na
Total Sulfate	na	na	na	na	na

IEPA North Slip - Bulk Sediment

	West Section	Middle Section	East Section		
	X-202	X-203	X-204	X-205	Average
VOCs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Benzene	na	na	na	na	na
Toluene	na	na	na	na	na
Ethylbenzene	na	na	na	na	na
m-Xylene	na	na	na	na	na
o-Xylene	na	na	na	na	na
p-Xylene	na	na	na	na	na
Pesticides	(ppb)	(ppb)	(ppb)	(ppb)	
alpha-BHC	na	na	na	na	na
beta-BHC	na	na	na	na	na
delta-BHC	4	2.6	4.8	4.8	4.8
gamma-BHC (Lindane)	na	na	na	na	na
Heptachlor	na	na	na	na	na
Aldrin	13	4.3	12	13	12.5
Heptachlor Epoxide	na	na	na	na	na
Endosulfan I	na	na	na	na	na
Dieldrin	5.8	2.1	6.3	7.3	6.8
4, 4'-DDE	na	na	na	na	na
Endrin	19	9.4	11	37	24
Endosulfan II	8.5	<5.5	7	7.6	7.3
4, 4'-DDD	4.8	2.6	4.3	5.2	4.75
Endosulfan sulfate	na	na	na	na	na
4, 4'-DDT	na	na	na	na	na
Methoxychlor	na	na	na	na	na
Endrin Ketone	12	<5.5	9.1	7	8.05
Chlordane	12.8	5.8	14.4	16.7	15.55
Toxaphene	220	<280	<320	<320	<320
Endrin Aldehyde	3	1.5	4.2	4.1	4.15

IEPA South Slip - Bulk Sediment

	X-208	X-209
Moisture Content (%)	51	47
TOC	0.050825	0.05083
Compound		
PAHs	(ppb)	(ppb)
Naphthalene	1600	14000
Acenapthylene	<3300	2500
Acenaphthene	<3300	2600
Fluorene	1100	3400
Phenanthrene	3700	13000
Anthracene	1200	5000
Fluoranthane	5000	17000
Pyrene	4600	15000
Chrysene	3100	12000
Benzo (a) anthracene	2800	12000
Benzo (b) fluoranthene	2300	9700
Benzo (k) fluoranthene	1600	6600
Benzo (a) pyrene	2600	9900
Dibenzo (a,h) anthracer	<3300	2100
Benzo (g,h,i) perylene	<3300	2400
Indno (1,2,3-cd) pyrene	2000	6500
Acetone	50	<19
2-Butanone	15	10
4-Methylphenol	940	1100
2-Methylnaphthalene	<3300	2200
Dibenzofuran	<3300	2700
Bis(2-ethylhexyl)phthala	na	na
PCBs	(ppb)	(ppb)
Arochlor 1242	790	2100
Arochlor 1248	na	na
Arochlor 1254	420	570
Arochlor 1260	190	350
Arochlor 1016	na	na
Arochlor 1221	na	na
Arochlor 1232	na	na
Metals	(ppm)	(ppm)
Arsenic	10.7262	8.3691
Cadmium	1.8585	2.0786
Chromium	139.122	34.8439
Copper	54.693	62.358
Iron	29948.4	36922.5
Lead	141.246	148.237
Mercury	0.7434	0.18598
Nickel	30.1077	22.8099
Selenium	0.2655	0.28991
Zinc	481.086	1049.69
Total Cyanide	2.124	0.8752
Ammonia-N	na	na
Total Sulfate	na	na

IEPA South Slip - Bulk S... ment

	X-208	X-209
VOCs	(ppb)	(ppb)
Benzene	na	na
Toluene	na	na
Ethylbenzene	na	na
m-Xylene	na	na
o-Xylene	na	na
p-Xylene	na	na
Pesticides	(ppb)	(ppb)
alpha-BHC	na	na
beta-BHC	na	na
delta-BHC	4.9	7.2
gamma-BHC (Lindane)	na	na
Heptachlor	na	na
Aldrin	18	57
Heptachlor Epoxide	na	na
Endosulfan I	na	na
Dieldrin	6.2	11
4, 4'-DDE	20	<6.1
Endrin	39	55
Endosulfan II	<6.7	18
4, 4'-DDD	5.4	12
Endosulfan sulfate	<6.7	3
4, 4'-DDT	9	<6.1
Methoxychlor	30	57
Endrin Ketone	na	na
Chlordane	na	na
Toxaphene	250	440
Endrin Aldehyde	4.1	5.4

USFWS North Slip - Bulk Sediment

	West End		Middle Section		East Section	
	USFWS Average	IEPA X-202	USFWS Average	IEPA X-203	USFWS Average	IEPA Average
Moisture Content (%)	60	63	53.5	40	48	47.5
TOC	0.0367	0.395	0.0423	0.042867	0.0496	0.042867
Compound						
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	945	1100	465	<2700	935	700
Acenapthylene	350	240	220	<2700	208.5	155
Acenaphthene	<660	190	<500	<2700	<500	130
Fluorene	255	410	140	<2700	300	350
Phenanthrene	980	1500	535	4100	1250	1100
Anthracene	380	480	210	1600	485	325
Fluoranthane	705	1200	<500	12000	1500	1100
Pyrene	1305	1200	<500	8400	2950	1450
Chrysene	1500	1500	690	6200	1900	1200
Benzo (a) anthracene	640	1100	375	6200	790	855
Benzo (b) fluoranthene	680	990	340	4600	710	600
Benzo (k) fluoranthene	295	670	230	3700	450	550
Benzo (a) pyrene	435	1000	410	4100	800	810
Dibenzo (a,h) anthracene	1195	<890	<300	<2700	945	<630
Benzo (g,h,i) perylene	<920	<890	<700	<2700	1400	<630
Indno (1,2,3-cd) pyrene	725	<890	415	2200	765	<630
Acetone	na	280	na	80	na	109
2-Butanone	na	62	na	15	na	28.5
4-Methylphenol	na	2400	na	<2700	na	<630
2-Methylnaphthalene	na	630	na	<2700	na	340
Dibenzofuran	na	350	na	<2700	na	200
Bis(2-ethylhexyl)phthalate	na	690	na	<2700	na	<630
PCBs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Arochlor 1242	<1200	480	<1000	<55	1280	525
Arochlor 1248	<2100	<89	<1900	180	<1600	420
Arochlor 1254	385	290	210	36	<3200	420
Arochlor 1260	<4200	150	<3700	78	<3200	160
Arochlor 1016	<2100	na	<1900	na	<1600	na
Arochlor 1221	<2100	na	<1900	na	<1600	na
Arochlor 1232	<2100	na	<1900	na	<1600	na
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Arsenic	16.65	5.9645	18.9	5.8296	15.35	9.4152
Cadmium	3.65	0.79	3.6	<0.59684	2.75	1.36455
Chromium	93.6	25.991	119	14.713	74.6	36.745
Copper	132	51.35	116.5	28.59	120.5	47.025
Iron	64050	24174	68700	27621.2	81850	43325.7
Lead	300	105.07	253.5	63.2928	248.5	98.241
Mercury	0.335	0.13825	0.46	0.21514	0.35	0.160365
Nickel	62.55	18.0515	55.85	13.12	52.15	25.08
Selenium	<1.3	0.3002	<1.2	0.22902	<1.1	<0.9741
Zinc	1003	309.285	936.5	174.888	974	331.326
Total Cyanide	1.8	<0.5135	3.4	1.1104	2.05	0.709575
Ammonia-N	na	na	na	na	na	na
Total Sulfate	na	na	na	na	na	na

USFWS North Slip - Bulk Sediment

	West End USFWS Average	West End IEPA X-202	Middle Section USFWS Average	Middle Section IEPA X-203	East Section USFWS Average	East Section IEPA Average
VOCs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Benzene	<5.0	na	<4.7	na	<4.0	na
Toluene	<5.0	na	<4.7	na	<4.0	na
Ethylbenzene	<5.0	na	<4.7	na	<4.0	na
m-Xylene	<5.0	na	<4.7	na	<4.0	na
o-Xylene	<5.0	na	<4.7	na	<4.0	na
p-Xylene	<5.0	na	<4.7	na	<4.0	na
Pesticides	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	
alpha-BHC	<53	na	<47	na	<40	na
beta-BHC	<110	na	<93	na	<80	na
delta-BHC	<160	4	<140	2.6	<120	4.8
gamma-BHC (Lindane)	<71	na	<63	na	<54	na
Heptachlor	<53	na	<47	na	<40	na
Aldrin	<71	13	<63	4.3	<54	12.5
Heptachlor Epoxide	<1500	na	<1300	na	<1100	na
Endosulfan I	<250	na	<220	na	<190	na
Dieldrin	<34	5.8	<30	2.1	<26	6.8
4, 4'-DDE	<71	na	<63	na	<54	na
Endrin	<21	19	<19	9.4	<80	24
Endosulfan II	<71	8.5	<63	<5.5	<54	7.3
4, 4'-DDD	<200	4.8	<170	2.6	<150	4.75
Endosulfan sulfate	<1200	na	<1000	na	<880	na
4, 4'-DDT	<210	na	<190	na	<160	na
Methoxychlor	<3100	na	<2700	na	<2400	na
Endrin Ketone	<420	12	<370	<5.5	na	8.05
Chlordane	<250	12.8	<220	5.8	<190	15.55
Toxaphene	<4300	220	<3800	<280	<3200	<320
Endrin Aldehyde	<390	3	<350	1.5	<300	4.15

USFWS South Slip - Bulk Sediment

	West End USFWS Average	West End IEPA X-208	Middle Section USFWS Average	East Section USFWS Average	East Section IEPA X-209
Moisture Content (%)	52	51	54	54.9	47
TOC	0.05625	0.050825	0.10165	0.0454	0.05083
Compound					
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	13500	1600	2900	2800	14000
Acenapthylene	2990	<3300	<5400	1565	2500
Acenaphthene	<5200	<3300	<5400	<5300	2600
Fluorene	2150	1100	1025	9800	3400
Phenanthrene	9200	3700	4460	55500	13000
Anthracene	3700	1200	1950	22200	5000
Fluoranthane	22500	5000	13000	79500	17000
Pyrene	12350	4600	7050	37000	15000
Chrysene	8900	3100	4500	24500	12000
Benzo (a) anthracene	5150	2800	2950	14950	12000
Benzo (b) fluoranthene	5500	2300	3050	14300	9700
Benzo (k) fluoranthene	2400	1600	1500	6000	6600
Benzo (a) pyrene	5150	2600	2900	14150	9900
Dibenzo (a,h) anthracene	12450	<3300	7000	31000	2100
Benzo (g,h,i) perylene	7500	<3300	3750	16800	2400
Indno (1,2,3-cd) pyrene	4850	2000	2600	11800	6500
Acetone	na	50	na	na	<19
2-Butanone	na	15	na	na	10
4-Methylphenol	na	940	na	na	1100
2-Methylnaphthalene	na	<3300	na	na	2200
Dibenzofuran	na	<3300	na	na	2700
Bis(2-ethylhexyl)phthalate	na	na	na	na	na
PCBs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Arochlor 1242	1400	790	3500	3800	2100
Arochlor 1248	<1700	na	<1700	<1700	na
Arochlor 1254	<3300	420	<3500	<3400	570
Arochlor 1260	<3300	190	<3500	<3400	350
Arochlor 1016	<1700	na	<1700	<1700	na
Arochlor 1221	<1700	na	<1700	<1700	na
Arochlor 1232	<1700	na	<1700	<1700	na
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Arsenic	13.1	10.7262	na	18.85	8.3691
Cadmium	3.25	1.8585	na	14.1	2.0786
Chromium	73.45	139.122	na	94.35	34.8439
Copper	108	54.693	na	130.5	62.358
Iron	50300	29948.4	na	87950	36922.5
Lead	239	141.246	na	626	148.237
Mercury	0.665	0.7434	na	0.385	0.18598
Nickel	45.5	30.1077	na	61.25	22.8099
Selenium	<1.1	0.2655	na	<1.1	0.28991
Zinc	996	481.086	na	1660	1049.69
Total Cyanide	2.3	2.124	na	3.2	0.8752
Ammonia-N	na	na	na	na	na
Total Sulfate	na	na	na	na	na

USFWS South Slip - Bulk Sediment

	West End		Middle Section	East Section	
	USFWS Average	IEPA X-208	USFWS Average	USFWS Average	IEPA X-209
VOCs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Benzene	4.15	na	<22	<4.3	na
Toluene	8.8	na	463.15	<4.3	na
Ethylbenzene	<4.2	na	<22	<4.3	na
m-Xylene	8.05	na	<22	<4.3	na
o-Xylene	7.25	na	<22	<4.3	na
p-Xylene	7.25	na	<22	<4.3	na
Pesticides	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
alpha-BHC	<42	na	<43	<43	na
beta-BHC	<83	na	<87	<85	na
delta-BHC	<120	4.9	<130	<130	7.2
gamma-BHC (Lindane)	<56	na	<59	<57	na
Heptachlor	<42	na	<43	<43	na
Aldrin	<56	18	<59	<57	57
Heptachlor Epoxide	<1200	na	<1200	<1200	na
Endosulfan I	<200	na	<200	<200	na
Dieldrin	<27	6.2	<28	<28	11
4, 4'-DDE	<56	20	<59	<57	<6.1
Endrin	<83	39	<87	<85	55
Endosulfan II	<56	<6.7	<59	<57	18
4, 4'-DDD	<160	5.4	<160	<160	12
Endosulfan sulfate	<920	<6.7	<960	<940	3.1
4, 4'-DDT	<170	8.5	<170	<170	<6.1
Methoxychlor	<2500	30	<2600	<2500	57
Endrin Ketone	na	na	na	na	na
Chlordane	<200	na	<200	<200	na
Toxaphene	<3300	250	<3500	<3400	440
Endrin Aldehyde	<310	4.1	<330	<320	5.4

North Slip

Compound	West End	Middle Section	East End
PAHs	(ppb)	(ppb)	(ppb)
Naphthalene	2972.97	1017.91	1983.49
Acenapthylene	925	475.81	436.17
Acenaphthene	<1736.8	<1000	<993.52
Fluorene	1108.11	306.05	634.94
Phenanthrene	4054.05	6833.33	2075.472
Anthracene	1297.3	2666.67	1026.48
Fluoranthane	3243.24	20000	3174.7
Pyrene	6052.63	14000	6249.1
Chrysene	4054.05	10333.33	4023.35
Benzo (a) anthracene	2972.97	10333.33	1672.99
Benzo (b) fluoranthene	2675.68	7666.67	1504.03
Benzo (k) fluoranthene	1810.81	6166.67	1169.811
Benzo (a) pyrene	2702.7	6833.33	1542.2715
Dibenzo (a,h) anthracene	3079.6055	<81.4	2006.23
Benzo (g,h,i) perylene	<1210.52	<188.37	2970.21
Indno (1,2,3-cd) pyrene	1856.579	3666.67	1622.82
Acetone	756.76	133.33	208.2003
2-Butanone	167.57	25	54.40856
4-Methylphenol	6486.49	<4500	<1211.538
2-Methylnaphthalene	1702.7	<4500	647.6778
Dibenzofuran	945.95	<4500	390.4209
Bis(2-ethylhexyl)phthalate	1864.86	<4500	<1211.538
PCBs			
Arochlor 1242	1297.3	<2325.6	2503.7
Arochlor 1248	<5526.3	<4418.6	807.6923
Arochlor 1254	992.8	446.05	799.5283
Arochlor 1260	405.41	<8604.7	304.6081
Arochlor 1016	<5526.3	<4418.6	<3200
Arochlor 1221	<5526.3	<4418.6	<3200
Arochlor 1232	<5526.3	<4418.6	<3200
Metals	(ppm)	(ppm)	(ppm)
Arsenic	42.9	40.71	29.54
Cadmium	9.4	7.819	5.3
Chromium	240.6	256.72	144
Copper	338.9	252.53	231.9
Iron	164427.6	148681.4	157981.5
Lead	770.4	550.3	478.7
Mercury	0.864	1.008	0.6733
Nickel	160.6	120.3	100.57
Selenium	<3.421	<2.791	<2.037
Zinc	2572.4	2043.93	1875
Total Cyanide	4.625	7.305	4
Ammonia-N	185.5	137.45	136.5
Total Sulfate	1056.9	1195.9	612.11
VOCs	(ppb)	(ppb)	(ppb)
Benzene	<13.95	<10.93	<8
Toluene	<13.95	<10.93	<8
Ethylbenzene	<13.95	<10.93	<8
m-Xylene	<13.95	<10.93	<8
o-Xylene	<13.95	<10.93	<8
p-Xylene	<13.95	<10.93	<8

North Slip

Compound	West End	Middle Section	East End
Pesticides	(ppb)	(ppb)	(ppb)
alpha-BHC	<139.47	<109.30	<83.33
beta-BHC	<289.47	<216.28	<166.67
delta-BHC	10.81	4.33	9.14
gamma-BHC (Lindane)	<186.84	<146.511	<112.5
Heptachlor	<139.474	<109.30	<83.33
Aldrin	35.14	7.17	23.8
Heptachlor Epoxide	<3947.37	<3023.26	<2291.67
Endosulfan I	<657.89	<511.63	<395.83
Dieldrin	15.68	3.5	12.94
4, 4'-DDE	<186.84	<146.51	<112.5
Endrin	51.35	15.67	45.48
Endosulfan II	22.97	<9.17	13.9
4, 4'-DDD	12.97	4.33	9.04
Endosulfan sulfate	<3157.89	<2325.58	<1833.33
4, 4'-DDT	<552.63	<441.86	<333.33
Methoxychlor	<8157.89	<6279.07	<5000
Endrin Ketone	32.43	<9.17	15.35
Chlordane	34.6	9.67	21.72
Toxaphene	594.59	466.67	<615.38
Endrin Aldehyde	8.11	2.5	7.9

South Slip

Compound	West End	Middle Section	East End
PAHs	(ppb)	(ppb)	(ppb)
Naphthalene	28123.5	6304.35	6205.6
Acenapthylene	6229.17	<11739.13	3460.94
Acenaphthene	10833.3	<11739.13	<11479.0
Fluorene	4479.17	2228.26	21649.3
Phenanthrene	19166.67	9695.65	122624.7
Anthracene	7708.33	4239.13	49049.9
Fluoranthane	46875	28260.87	175781.9
Pyrene	25729.17	15326.09	81815.37
Chrysene	18541.67	9782.61	54182.22
Benzo (a) anthracene	10729.17	6413.04	33060.22
Benzo (b) fluoranthene	11458.34	6630.44	31622.39
Benzo (k) fluoranthene	5000	3260.87	13269.62
Benzo (a) pyrene	10729.17	6304.35	31288.32
Dibenzo (a,h) anthracene	25437.5	15217.39	68540.83
Benzo (g,h,i) perylene	15625	8152.17	37150.99
Indno (1,2,3-cd) pyrene	10104.17	5652.17	26093.9
Acetone	102.04	-	<35.85
2-Butanone	30.61	-	18.87
4-Methylphenol	1918.37	-	2075.47
2-Methylnaphthalene	<6734.69	-	4150.94
Dibenzofuran	<6734.69	-	5094.34
Bis(2-ethylhexyl)phthalate	-	-	-
PCBs			
Arochlor 1242	2916.7	7608.7	8005.3
Arochlor 1248	<3541.7	<3695.7	<3617.02
Arochlor 1254	<6875	<7608.7	<7234.04
Arochlor 1260	<6875	<7608.7	<7234.04
Arochlor 1016	<3541.7	<8034.03	<3617.02
Arochlor 1221	<3541.7	<8034.03	<3617.02
Arochlor 1232	<3541.7	<8034.03	<3617.02
Metals	(ppm)	(ppm)	(ppm)
Arsenic	27.3	DATA MISSING	39.7
Cadmium	6.77		19.5
Chromium	262		199
Copper	129.2		275.04
Iron	104791.7		185467
Lead	497.9		1321.15
Mercury	1.385		0.808
Nickel	94.79		129.08
Selenium	<2.292		<2.3404
Zinc	2075		3502.44
Total Cyanide	4.792		13.49
Ammonia-N	199.8		161.19
Total Sulfate	1576.04		1339.3
VOCs	(ppb)	(ppb)	(ppb)
Benzene	8.646	<47.8	<9.149
Toluene	18.33	1006.85	<9.149
Ethylbenzene	<8.75	<28.58	<9.149
m-Xylene	16.78	<28.58	<9.149
o-Xylene	15.1	<28.58	<9.149
p-Xylene	15.1	<28.58	<9.149

South Slip

Compound	West End	Middle Section	East End
Pesticides	(ppb)	(ppb)	(ppb)
alpha-BHC		<80.44	
beta-BHC		<173.91	
delta-BHC	10	<260.87	13.58
gamma-BHC (Lindane)		<117.39	
Heptachlor		<86.96	
Aldrin	36.73	<117.39	107.55
Heptachlor Epoxide		<2391.30	
Endosulfan I		<413.04	
Dieldrin	12.65	<56.52	20.76
4, 4'-DDE	40.81	<117.39	11.51
Endrin	79.59	<173.91	103.77
Endosulfan II	<13.67	<117.39	33.96
4, 4'-DDD	11.02	<326.09	22.64
Endosulfan sulfate	<13.67	<1913.04	5.85
4, 4'-DDT	17.35	<347.83	11.51
Methoxychlor	61.22	5217.39	107.55
Endrin Ketone	<7291.67	-	-
Chlordane	38.9796	<413.04	52.83
Toxaphene	510.2	6956.52	830.19
Endrin Aldehyde	8.37	<652.17	10.19

$$[\text{Chemical}]_{\text{dry weight}} = \frac{[\text{Chemical}]_{\text{wet weight}}}{(1 - \text{Moisture})}$$

$[\text{Chemical}]_{\text{wetweight}}$	Wet weight concentration of chemical (mg/kg or µg/kg)	Appendix D
$[\text{Chemical}]_{\text{dryweight}}$	Dry weight concentration of chemical (mg/kg or µg/kg)	Appendix D
Moisture	Moisture content expressed as a decimal fraction (i.e. 60% Moisture = 0.60)	Appendix D

Appendix D
Sediment Chemistry
Screening Values

Compound	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	SQUAL (ppm)	TEL (ppm)	PEL (ppm)
PAHs							
Naphthalene	0.16	2.1	2.1	2.7	47	0.0346	0.391
Acenapthylene	0.044	0.64	1.3	1.3		0.00587	0.128
Acenaphthene	0.016	0.5	0.5	2	130	0.00671	0.0889
Fluorene	0.019	0.54	0.54	3.6	54	0.0212	0.144
Phenanthrene	0.24	1.5	1.5	6.9	180	0.0867	0.544
Anthracene	0.0853	1.1	0.96	13		0.0469	0.245
Fluoranthane	0.6	5.1	2.5	30	620	0.113	1.494
Pyrene	0.665	2.6	3.3	16		0.153	1.398
Chrysene	0.384	2.8	2.8	9.2		0.108	0.846
Benzo (a) anthracene	0.261	1.6	1.6	5.1		0.0748	0.693
Benzo (b) fluoranthene			3.6	9.9			
Benzo (k) fluoranthene			3.6	9.9			
Benzo (a) pyrene	0.43	1.6	1.6	3.6		0.0888	0.763
Dibenzo (a,h) anthracene	0.0634	0.26	0.23	0.97		0.00622	0.135
Benzo (g,h,i) perylene			3.6	9.9			
Indno (1,2,3-cd) pyrene			0.69	2.6			
Acetone							
2-Butanone							
4-Methylphenol							
2-Methylnaphthalene	0.07	0.67	0.67	1.9		0.0202	0.201
Dibenzofuran			0.54	1.7	200		
Bis(2-ethylhexyl)phthalate			1.3	1.9		0.182	2.65
PCBs							
Arochlor 1242	0.0227	0.18	1	3.1		0.0216	0.189
Arochlor 1248	0.0227	0.18	1	3.1		0.0216	0.189
Arochlor 1254	0.0227	0.18	1	3.1		0.0216	0.189
Arochlor 1260	0.0227	0.18	1	3.1		0.0216	0.189
Arochlor 1016	0.0227	0.18	1	3.1		0.0216	0.189
Arochlor 1221	0.0227	0.18	1	3.1		0.0216	0.189
Arochlor 1232	0.0227	0.18	1	3.1		0.0216	0.189
Metals							
Arsenic	8.2	70	57	700		7.24	41.6
Cadmium	1.2	9.6	5.1	9.6		0.676	4.21
Chromium	81	370	260	270		52.3	160
Copper	34	270	390	1300		18.7	108
Iron							
Lead	46.7	218	450	660		30.2	112
Mercury	0.15	0.71	0.59	2.1		0.13	0.696
Nickel	20.9	51.6				15.9	42.8
Selenium							
Zinc	150	410	410	1600		124	271
Cyanide							
VOCs							
Benzene					5.7		
Toluene					89		
Ethylbenzene			0.01	0.037	480		
m-Xylene			0.04	0.12	2.5		
o-Xylene			0.04	0.12	2.5		
p-Xylene			0.04	0.12	2.5		

Appendix D
Sediment Chemistry
Screening Values

Compound	ER-L (ppm)	ER-M (ppm)	AET-L (ppm)	AET-H (ppm)	SQUAL (ppm)	TEL (ppm)	PEL (ppm)
Pesticides							
alpha-BHC						0.00032	0.00099
beta-BHC						0.00032	0.00099
delta-BHC					13	0.00032	0.00099
gamma-BHC (Lindane)					0.37	0.00032	0.00099
Heptachlor							
Aldrin							
Heptachlor Epoxide							
Endosulfan I					0.29		
Dieldrin					11	0.000715	0.0043
4, 4'-DDE	0.0022	0.027	0.009	0.015		0.00207	0.374
Endrin					4.2		
Endosulfan II					1.4		
4, 4'-DDD	0.00158	0.027	0.016	0.043		0.00122	0.00781
Endosulfan sulfate							
4, 4'-DDT	0.00158	0.027	0.034	0.034		0.00119	0.00477
Methoxychlor					1.9		
Endrin Ketone							
Chlordane						0.00226	0.00479
Toxaphene							
Endrin Aldehyde							

	IEPA Classification of Illinois Stream Sediments			WSW North Slip*			WSW South Slip*		
mical	Non-elevated	Elevated	Extreme	West End	Middle Section	East End	West End	Middle Section	East End
nic	<8.0	>8.0	>28	**42.9**	**40.71**	**29.54**	27.3	DATA MISSING	39.7
omium	<16	>23	>60	**240.6**	**256.72**	**144**	**262**		199
per	<38	>60	>200	**338.9**	**252.53**	**231.9**	129.2		275.04
	<18000	>23000	>50000	**164427.6**	**148681.4**	**157981.5**	**104791.7**		185467
d	<28	>38	>100	**770.4**	**550.3**	**478.7**	**497.9**		1321.15
ganese	<1300	>1800	>5000	**6360**	1160	1770	1280		1990
cury	<0.07	>0.10	>0.30	**0.864**	**1.008**	**0.6733**	**1.385**		0.808
;	<80	>100	>300	**2572.4**	**2043.93**	**1875**	**2075**		3502.44
mium	<0.5	>1.0	>20.0	9.4	7.819	5.3	6.77		19.5
s									
lor 1242	<10	>50	>1500	1297.3	**<2325.6**	**2503.7**	**2916.7**	**7608.7**	8005.3
lor 1248	<10	>50	>1500	<5526.3	<4418.6	807.6923	**<3541.7**	**<3695.7**	<3617.02
lor 1254	<10	>50	>1500	992.8	446.05	799.5283	**<6875**	**<7608.7**	<7234.04
lor 1260	<10	>50	>1500	405.41	<8604.7	304.6081	**<6875**	**<7608.7**	**<7234.04**
lor 1016	<10	>50	>1500	**<5526.3**	**<4418.6**	**<3200**	**<3541.7**	**<8034.03**	<3617.02
lor 1221	<10	>50	>1500	**<5526.3**	**<4418.6**	**<3200**	**<3541.7**	**<8034.03**	<3617.02
lor 1232	<10	>50	>1500	**<5526.3**	**<4418.6**	**<3200**	**<3541.7**	**<8034.03**	<3617.02

ncentrations in bold represent values above the extreme classification of Illinois Stream Sediments

APPENDIX E

IEPA Surface Water Data
Ambient Water Quality Criteria

	USFWS North Slip			USFWS South Slip				
Compound	**West End (ppb)**	**Middle Section (ppb)**	**East End (ppb)**	**West End (ppb)**	**Middle Section (ppb)**	**East End (ppb)**	**CMC (ppb)**	**CCC (ppb)**
Chloroform	3	3	3	3	-	3		
Benzene	-	-	-	8	-	<10	na	na
Toluene	-	-	-	<10	-	<10	na	na
Aluminium	334	208	295	574	-	654		
Arsenic	<1	<1	1.2	1.2	-	1.8	340	150
Barium	26.4	24.6	25.5	27.3	-	27.6		
Cadmium	<4	<4	4.3	-	-		4.3	2.2
Calcium	43900	40400	39850	40100	-	40200		
Copper	<9	6.7	<9	-	-		13	9
Iron	361	258	330.5	602	-	642		1000
Lead	3.1	3.3	2.6	4	-	4.1	65	2.5
Magnesium	14100	11900	11800	11900	-	12000		
Manganese	38.4	33.3	33.15	43.7	-	53.4		
Nickel	17.5	24.7	<14	<14	-	<14	470	52
Potassium	4060	2690	2480	2100	-	3070		
Sodium	37500	37800	38100	37500	-	36900		
Zinc	11.2	9.8	8.55	13.8	-	14.5	120	120

APPENDIX F

Macroinvertebrate Regression Analysis

Comparison of WSW Sediment Chemistry to Ontario Sediment Quality Guidelines

Sampling Station	Organisms	Naphthalene (ppb)	Acenapthylene (ppb)	Acenaphthene (ppb)	Fluorene (ppb)	Phenanthrene (ppb)	Anthracene (ppb)	Fluoranthane (ppb)	Pyrene (ppb)	Chrysene (ppb)
1	18	2342.11	868.42	868.42	631.58	2263.16	921.05	2894.74	6052.63	3421.05
2	11	2500.00	925.00	775.00	675.00	2750.00	512.50	775.00	775.00	4250.00
3	25	1255.81	511.63	67.44	372.09	1418.61	534.88	67.44	67.44	67.44
4	16	780.00	440.00	500.00	240.00	920.00	380.00	500.00	500.00	1380.00
9	7	2008.64	101.51	496.76	561.56	2375.81	907.13	2807.78	5831.53	3671.71
10	10	1958.33	770.83	520.83	708.33	2916.67	1145.83	3541.67	6666.67	4375.00
5	11	33333.33	5416.67	5416.67	5208.33	22916.67	8958.33	56250.00	31250.00	22916.67
6	29	22916.67	1625.00	5416.67	3750.00	15416.67	6458.33	37500.00	20208.33	14166.67
7	12	6956.52	5869.57	5869.57	2391.30	10217.39	4565.22	28260.87	15652.17	9565.22
8	2	5652.17	5869.57	5869.57	2065.22	9173.91	3913.04	28260.87	15000.00	10000.00
11	3	5567.93	1403.12	5902.00	3563.47	24498.89	9799.55	64587.97	31180.40	[illegible]
12	1	6843.27	5518.76	5739.51	39735.10	220750.55	88300.22	286975.72	132450.33	86092.72
	Correlation	0.19	-0.44	-0.34	-0.41	-0.42	-0.42	-0.45	-0.46	-0.46

Sampling Station	Benzo (a) anthracene (ppb)	Benzo (b) fluoranthene (ppb)	Benzo (k) fluoranthene (ppb)	Benzo (a) pyrene (ppb)	Dibenzo (a,h) anthracene (ppb)	Benzo (g,h,i) perylene (ppb)	Indno (1,2,3-cd) pyrene (ppb)	ΣPAHs (ppb)
1	1631.58	1578.95	1026.32	1631.58	3684.21	1210.50	1763.16	32789.45
2	1650.00	1900.00	500.00	625.00	2475.00	1100.00	1950.00	24137.50
3	953.49	22.09	22.09	1046.51	40.70	94.19	976.74	7518.61
4	680.00	680.00	460.00	740.00	300.00	700.00	820.00	10020.00
9	1533.48	1403.89	907.13	1641.47	2116.63	3023.76	1641.47	31030.24
10	1812.50	1604.17	1000.00	1750.00	1895.83	2916.67	1604.17	35187.50
5	12916.67	13750.00	6041.67	12708.33	31250.00	18541.67	12083.33	298958.33
6	8541.67	9166.67	3958.33	8750.00	20625.00	12708.33	8125.00	199333.33
7	6304.35	6521.74	3260.87	6089.96	15217.39	8913.04	5652.17	141307.35
8	6521.74	6736.13	3260.87	6521.74	3586.96	7391.30	5652.17	125475.26
11	13140.31	12472.16	5567.93	11804.01	24498.89	14699.33	10244.99	261202.67
12	52980.13	50772.63	20971.30	50772.63	112582.78	59602.65	41942.60	1262030.91
Correlation	-0.45	-0.45	-0.46	-0.44	-0.39	-0.43	-0.43	-0.43

Sampling Station	Aroclor 1242 (ppb)	Aroclor 1248 (ppb)	Aroclor 1254 (ppb)	Aroclor 1260 (ppb)	ΣPCBs (ppb)
1	1578.95	2763.16	1210.53	5526.32	11078.95
2	1375.00	2500.00	775.00	5000.00	9650.00
3	1162.79	2209.30	372.09	4302.33	8046.51
4	880.00	1600.00	520.00	3200.00	6200.00
9	1641.47	1619.87	3239.74	3239.74	9740.82
10	3750.00	1666.67	3333.33	3333.33	12083.33
5	2500.00	1770.84	3437.50	3437.50	11145.84
6	3333.33	1770.85	3437.50	3437.50	11979.18
7	7391.30	1770.85	3804.35	3804.35	16770.85
8	7826.09	1847.85	3804.35	3804.35	17282.64
11	8908.69	1808.51	3786.19	3786.19	18289.58
12	7947.02	1770.84	3624.38	3642.38	16984.62
Correlation	-0.62	0.28	-0.50	0.19	-0.60

Sampling Station	Organisms	Arsenic (ppm)	Cadmium (ppm)	Chromium (ppm)	Copper (ppm)	Lead (ppm)	Mercury (ppm)	Nickel (ppm)	Selenium (ppm)	Zinc (ppm)
1	18	50.79	11.05	265.79	357.89	815.79	1.05	166.84	1.71	2594.74
2	11	35.00	7.75	215.50	320.00	725.00	0.68	154.25	1.63	2550.00
3	25	41.63	8.84	267.44	279.07	618.60	1.26	122.79	1.40	2441.86
4	16	39.80	6.80	246.00	226.00	482.00	0.76	117.80	1.00	1646.00
9	7	33.69	5.83	152.92	265.66	533.48	0.78	108.64	1.19	2129.59
10	10	31.46	5.83	163.33	245.83	520.83	0.71	112.50	1.04	2004.17
5	11	25.83	6.67	145.00	212.50	477.08	1.65	91.04	1.15	1962.50
6	29	28.75	6.88	161.04	237.50	518.75	1.13	98.54	1.04	2187.50
11	3	42.32	12.03	244.99	318.49	1703.79	0.56	148.11	1.22	4432.07
12	1	41.28	50.33	173.73	260.49	1075.06	1.15	123.62	1.21	2935.98
	Correlation	-0.07	-0.48	0.25	-0.10	-0.53	0.33	-0.17	0.05	-0.44

USFWS North Slip

Compound	West End	Middle Section	East End	LEL	SEL	West End Adjusted SEL	Middle Section Adjusted SEL	East End Adjusted SEL
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	2973.0	1017.9	1983.5					
Acenapthylene	925.0	475.8	436.2					
Acenaphthene	<1736.8	<1000	<993.52					
Fluorene	1108.1	306.1	634.9	190.0	160000.0	5872	6768	7930
Phenanthrene	4054.1	6833.3	2075.5	560.0	950000.0	34865	40185	47120
Anthracene	1297.3	2666.7	1026.5	220.0	370000.0	13579	15651	18352
Fluoranthane	3243.2	20000.0	3174.7	750.0	1020000.0	37434	43146	50592
Pyrene	6052.6	14000.0	6249.1	490.0	850000.0	31195	35955	42160
Chrysene	4054.1	10333.3	4023.4	340.0	460000.0	16882	19458	22816
Benzo (a) anthracene	2973.0	10333.3	1673.0	320.0	1480000.0	54316	62604	73408
Benzo (b) fluoranthene	2675.7	7666.7	1504.0					
Benzo (k) fluoranthene	1810.8	6166.7	1169.8	240.0	1340000.0	49178	56682	66464
Benzo (a) pyrene	2702.7	6833.3	1542.3	370.0	1440000.0	52848	60912	71424
Dibenzo (a,h) anthracene	3079.6	<81.4	2006.2	60.0	130000.0	4771	5499	6448
Benzo (g,h,i) perylene	<1210.52	<188.37	2970.2	170.0	320000.0	11744	13536	15872
Indno (1,2,3-cd) pyrene	1856.6	3666.7	1622.8	200.0	320000.0	11744	13536	15872
4-Methylphenol	6486.5	<4500	<1211.538					
2-Methylnaphthalene	1702.7	<4500	647.7					
Dibenzofuran	946.0	<4500	390.4					
PCBs								
Arochlor 1242	1297.3	<2325.6	2503.7					
Arochlor 1248	<5526.3	<4418.6	807.7	30.0	150000.0	5505	6345	7440
Arochlor 1254	992.8	446.1	799.5	60.0	34000.0	1247.8	1438.2	1686.4
Arochlor 1260	405.4	<8604.7	304.6	5.0	24000.0	880.8	1015.2	1190.4
Arochlor 1016	<5526.3	<4418.6	<3200	7.0	53000.0	1945.1	2241.9	2628.8
Arochlor 1221	<5526.3	<4418.6	<3200					
Arochlor 1232	<5526.3	<4418.6	<3200					
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)			
Arsenic	42.9	40.7	29.5	6.0	33.0			
Cadmium	9.4	7.8	5.3	0.6	10.0			
Chromium	240.6	256.7	144.0	26.0	110.0			
Copper	338.9	252.5	231.9	16.0	110.0			
Lead	770.4	550.3	478.7	31.0	250.0			
Mercury	0.9	1.0	0.7		2.0			
Nickel	160.6	120.3	100.6	16.0	75.0			
Selenium	<3.421	<2.791	<2.037					
Zinc	2572.4	2043.9	1875.0	120.0	820.0			

USFWS South Slip

Compound	West End	Middle Section	East End	LEL	SEL	West End Adjusted SEL	Middle Section Adjusted SEL	East End Adjusted SEL
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	28123.5	6304.35	6205.6					
Acenapthylene	6229.17	<11739.13	3460.94					
Acenaphthene	10833.3	<11739.13	<11479.0					
Fluorene	4479.17	2228.26	21649.3	190	160000	5872	6768	7936
Phenanthrene	19166.67	9695.65	122624.7	560	950000	34865	40185	47120
Anthracene	7708.33	4239.13	49049.9	220	370000	13579	15651	18352
Fluoranthane	46875	28260.87	175781.9	750	1020000	37434	43146	50592
Pyrene	25729.17	15326.09	81815.37	490	850000	31195	35955	42160
Chrysene	18541.67	9782.61	54182.22	340	460000	16882	19458	22816
Benzo (a) anthracene	10729.17	6413.04	33060.22	320	1480000	54316	62604	73408
Benzo (b) fluoranthene	11458.34	6630.44	31622.39					
Benzo (k) fluoranthene	5000	3260.87	13269.62	240	1340000	49178	56682	66464
Benzo (a) pyrene	10729.17	6304.35	31288.32	370	1440000	52848	60912	71424
Dibenzo (a,h) anthracene	25437.5	15217.39	68540.83	60	130000	4771	5499	6448
Benzo (g,h,i) perylene	15625	8152.17	37150.99	170	320000	11744	13536	15872
Indno (1,2,3-cd) pyrene	10104.17	5652.17	26093.9	200	320000	11744	13536	15872
4-Methylphenol	1918.37	-	2075.47					
2-Methylnaphthalene	<6734.69	-	4150.94					
Dibenzofuran	<6734.69	-	5094.34					
PCBs								
Arochlor 1242	2916.7	7608.7	8005.3					
Arochlor 1248	<3541.7	<3695.7	<3617.02	30	150000	5505	6345	[illegible]
Arochlor 1254	<6875	<7608.7	<7234.04	60	34000	1247.8	1438.2	1686.4
Arochlor 1260	<6875	<7608.7	<7234.04	5	24000	880.8	1015.2	1190.4
Arochlor 1016	<3541.7	<8034.03	<3617.02	7	53000	1945.1	2241.9	2628.8
Arochlor 1221	<3541.7	<8034.03	<3617.02					
Arochlor 1232	<3541.7	<8034.03	<3617.02					
Metals	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)			
Arsenic	27.3	DATA MISSING	39.7	6	33			
Cadmium	6.77		19.5	0.6	10			
Chromium	262		199	26	110			
Copper	129.2		275.04	16	110			
Lead	497.9		1321.15	31	250			
Mercury	1.385		0.808		2			
Nickel	94.79		129.08	16	75			
Selenium	<2.292		<2.3404					
Zinc	2075		3502.44	120	820			

APPENDIX G

Sample calculation of TBPs

F_{lipid} for species of fish found in vessel slips

BSAFs for chemicals

TBPs for White perch, Alewife, and Common carp.

Sample Calculation of TBPs:

$$C_{fish} = \frac{C_{sb} * f_{lipid} * BSAF}{TOC_{sed}}$$

C_{fish}	Concentration of chemical in fish tissue (mg/kg)	Calculated
C_{sb}	dry weight concentration of chemical sorbed to the sediments (mg/kg)	Appendix D
f_{lipid}	fish lipid content expressed as a decimal fraction (unitless)	Appendix G
BSAF	Chemical-specific Biota to Sediment Accumulation Factor (unitless)	Appendix G
TOC_{sed}	Fraction of organic carbon found in sediments expressed as a decimal fraction (unitless)	Appendix D

White Perch (North Slip):
Sample Calculation for Fluorene:

West End	Middle Section	East End
C_{sb} = 1.108 mg/kg	C_{sb} = 0.306 mg/kg	C_{sb} = 0.635 mg/kg
f_{lipid} = 0.045	f_{lipid} = 0.045	f_{lipid} = 0.045
BSAF = 0.29	BSAF = 0.29	BSAF = 0.29
TOC_{sed} = 0.0367	TOC_{sed} = 0.0423	TOC_{sed} = 0.0496
C_{fish} = 0.394	C_{fish} = 0.094	C_{fish} = 0.167

$$C_{fish}\text{ Average} = \frac{(C_{fish}\text{ West End}) + (C_{fish}\text{ Middle Section}) + (C_{fish}\text{ East End})}{3}$$

C_{fish} Average = 0.219 mg/kg

North Barge Slip		Whole Fish Lipid Content
Common name	Scientific name	Percent
Alewife	*Alosa pseudoharengus*	7
White Perch	*Morone americanus*	4.5
Gizzard Shad	*Dorosoma cepedianum*	7.4
Common Carp	*Cyprinus carpio*	17.5
Channel catfish	*Ictalurus punctatus*	7.1
South Barge Slip		
White Perch	*Morone americanus*	4.5
Gizzard Shad	*Dorosoma cepedianum*	7.4
Common Carp	*Cyprinus carpio*	17.5
Channel catfish	*Ictalurus punctatus*	7.1

Compound	BSAF
Naphthalene	0.29
Acenaphthylene	0.29
Acenaphthene	0.29
Fluorene	0.29
Phenanthrene	0.29
Anthracene	0.29
Fluoranthene	0.29
Pyrene	0.29
Chrysene	0.29
Benzo(a)anthracene	0.29
Benzo(b)fluoranthene	0.29
Benzo(k)fluoranthene	0.29
Benzo(a)pyrene	0.29
Dibenzo(a,h)anthracene	0.29
Benzo(g,h,l)perylene	
Indeno(1,2,3-cd)pyrene	0.29
Aroclor 1242	1.85
Aroclor 1254	1.85
Aroclor 1248	1.85
Arsenic	NA
Cadmium	NA
Chromium	NA
Copper	NA
Lead	NA
Mercury	NA
Nickel	NA
Selenium	NA
Zinc	NA
Total Cyanide	NA
Benzene	1
Toluene	1
Ethylbenzene	1
m-Xylene	1
o-Xylene	1
p-Xylene	1

ːmical-specific BSAFs
ɪrce: National Sediment
ılity Survey, 1998)

Chemical (ppm)	White Perch North Slip Average	White Perch South Slip Average	Common carp North Slip Average	Common carp South Slip Average	Alewife North Slip Average
PAHs					
Naphthalene	0.631	3.309	2.454	12.869	0.982
Acenapthylene	0.197	1.316	0.765	5.117	0.306
Acenaphthene	0.198	1.890	0.770	7.350	0.308
Fluorene	0.219	2.611	0.850	10.156	0.340
Phenanthrene	1.365	14.061	5.309	54.683	2.124
Anthracene	0.518	5.659	2.015	22.006	0.806
Fluoranthane	2.720	22.886	10.576	89.002	4.230
Pyrene	2.705	11.141	10.520	43.325	4.208
Chrysene	1.896	7.463	7.373	29.021	2.949
Benzo (a) anthracene	1.562	4.546	6.073	17.680	2.429
Benzo (b) fluoranthene	1.237	4.483	4.812	17.436	1.925
Benzo (k) fluoranthene	0.951	1.937	3.700	7.533	1.480
Benzo (a) pyrene	1.158	4.367	4.505	16.984	1.802
Dibenzo (a,h) anthracene	0.545	9.837	2.120	38.254	0.848
Benzo (g,h,i) perylene	0.342	5.466	1.330	21.255	0.532
Indno (1,2,3-cd) pyrene	0.739	3.765	2.876	14.643	1.150
Acetone	0.122	0.014	0.473	0.056	0.189
2-Butanone	0.027	0.006	0.106	0.024	0.042
4-Methylphenol	1.053	0.521	4.096	2.025	1.639
2-Methylnaphthalene	0.490	0.987	1.906	3.839	0.762
Dibenzofuran	0.378	1.123	1.469	4.366	0.588
Bis(2-ethylhexyl)phthalate	0.506	-	1.966	-	0.786
PCBs Aroclors					
Aroclor 1242	3.357	10.486	13.057	40.780	5.223
Aroclor 1248	4.434	3.473	17.243	11.620	6.897
Aroclor 1254	2.834	6.926	11.020	23.270	4.408
Aroclor 1260	8.792	6.926	34.189	23.270	13.676
Aroclor 1016	4.434	4.658	17.243	16.228	6.897
Aroclor 1221	4.434	4.658	17.243	16.228	6.897
Aroclor 1232	4.434	4.658	17.243	16.228	6.897

APPENDIX H

Toxicity Test Correlation Analysis
Equilibrium Partitioning Model Methodology
Calculated Aqueous concentrations of PAHs and PCBs using Equilibrium Partitioning Model.

Sampling Station	0 to 48-hr % Mortality	48 to 96-hr % Mortality	Naphthalene (ppb)	Acenapthylene (ppb)	Anthracene (ppb)	Benzo (a) pyrene (ppb)
1a	0	0	65.40	9.12	1.73	0.01
3a	0	15	34.34	5.26	0.98	0.00
9b	5	5	42.99	0.82	1.30	0.01
9a	5	0	42.99	0.82	1.30	0.01
5a	20	10	619.95	37.88	11.19	0.04
7b	5	5	145.59	46.19	6.42	0.02
7a	5	0	145.59	46.19	6.42	0.02
11a	0	10	128.77	12.20	15.22	0.05
11b	5	0	128.77	12.20	15.22	0.05
1a	5	0	65.40	9.12	1.73	0.01
1b	0	0	65.40	9.12	1.73	0.01
2a	0	0	75.34	10.48	1.04	0.00
2b	0	0	75.34	10.48	1.04	0.00
5a	25	10	619.95	37.88	11.19	0.04
5b	25	10	619.95	37.88	11.19	0.04
6a	45	20	440.86	11.75	8.34	0.03
6b	35	15	440.86	11.75	8.34	0.03
	Correlation 48-hr:		0.82	0.25	0.43	0.49
	Correlation 96-hr:		0.61	0.10	0.39	0.43

Acenaphthene (ppb)	Fluorene (ppb)	Phenanthrene (ppb)	Fluoranthane (ppb)	Pyrene (ppb)	Arochlor 1242 (ppb)	Arochlor 1248 (ppb)
5.07	2.27	4.24	2.00	4.18	0.00	0.00
0.39	1.31	2.60	0.05	0.05	0.00	0.00
2.22	1.55	3.41	1.49	3.09	0.00	0.00
2.22	1.55	3.41	1.49	3.09	0.00	0.00
21.04	12.47	28.62	25.88	14.38	0.00	0.00
25.66	6.44	14.36	14.63	8.10	0.00	0.00
25.66	6.44	14.36	14.63	8.10	0.00	0.00
28.51	10.61	38.04	36.95	17.84	0.00	0.00
28.51	10.61	38.04	36.95	17.84	0.00	0.00
5.07	2.27	4.24	2.00	4.18	0.00	0.00
5.07	2.27	4.24	2.00	4.18	0.00	0.00
4.88	2.62	5.56	0.58	0.58	0.00	0.00
4.88	2.62	5.56	0.58	0.58	0.00	0.00
21.04	12.47	28.62	25.88	14.38	0.00	0.00
21.04	12.47	28.62	25.88	14.38	0.00	0.00
21.77	9.29	19.91	17.85	9.62	0.00	0.00
21.77	9.29	19.91	17.85	9.62	0.00	0.00
0.45	0.64	0.42	0.40	0.43	-0.17	-0.58
0.34	0.50	0.38	0.37	0.33	-0.09	-0.52

Arochlor 1254 (ppb)	Ammonia 0 to 48-hr (ppb)	Ammonia 48 to 96-hr (ppb)
0.00	410	10
0.00	150	10
0.00	270	10
0.00	310	10
0.00	1500	140
0.00	730	660
0.00	470	500
0.00	370	280
0.00	380	290
0.00	620	390
0.00	620	370
0.00	390	180
0.00	330	170
0.00	1100	630
0.00	1500	680
0.00	1300	920
0.00	1300	830
0.32	0.86	
0.15		0.50

$Kd_{bs} = TOC_{sed} \cdot K_{oc}$		
Kd_{bs}	Bottom sediment-sediment pore water partitioning coefficient (ml/g)	
TOC_{sed}	Total organic content of the sediment expressed as a decimal fraction (i.e 1% = 0.01)	Appendix D
K_{oc}	Organic carbon partitioning coefficient	Appendix H

$C_w = \frac{Cs}{Kd_{bs}}$		
C_w	Concentration chemical in water (mg/l, ppm)	
Cs	Dry weight concentration chemical in water (mg/l, ppm)	Appendix D
Kd_{bs}	Bottom sediment-sediment pore water partitioning coefficient (ml/g)	Calculated using above equation

Compound	Koc (ml/g)	WSW 5-A+B (ppb)	Kd$_{bs}$	TOC	Cw (mg/L)	WSW 6-A+B (ppb)	Kd$_{bs}$	OCsed	Cw (mg/L)	WSW 7-A+B (ppb)	Kd, bs	OCsed	Cw (mg/L)
PAHs				0.0572				0.0553				0.0508	
Naphthalene	940	33333.3	53.768		0.619947428	**22916.7**	51.982		0.440857733	**6956.5**	47.7802		0.145594237
Acenapthylene	2500	5416.7	143		0.037878776	**1625.0**	138.25		0.011754069	**5869.6**	127.075		0.046189771
Acenaphthene	4500	5416.7	257.4		0.021043765	**5416.7**	248.85		0.021766787	**5869.6**	228.735		0.025660984
Fluorene	7300	5208.3	417.56		0.012473249	**3750.0**	403.69		0.009289306	**2391.3**	371.059		0.006444539
Phenanthrene	14000	22916.7	800.8		0.02861722	**15416.7**	774.2		0.019913029	**10217.4**	711.62		0.014357932
Anthracene	14000	8958.3	800.8		0.011186726	**6458.3**	774.2		0.00834194	**4565.2**	711.62		0 006415246
Fluoranthane	38000	56250.0	2173.6		0.025878727	**37500.0**	2101.4		0.017845246	**28260.9**	1931.54		0.014631263
Pyrene	38000	31250.0	2173.6		0.01437707	**20208.3**	2101.4		0.009616603	**15652.2**	1931.54		0.008103469
Chrysene	200000	22916.7	11440		0.002003205	**14166.7**	11060		0.001280892	**9565.2**	10166		0.000940903
Benzo (a) anthracene	1380000	12916.7	78936		0.000163635	**8541.7**	76314		0.000111928	**6304.3**	70145.4		8.98754E-05
Benzo (b) fluoranthene	550000	13750.0	31460		0.000437063	**9166.7**	30415		0.000301386	**6521.7**	27956.5		0.000233282
Benzo (k) fluoranthene	550000	6041.7	31460		0.000192043	3958.3	30415		0.000130144	3260.9	27956.5		0 000116641
Benzo (a) pyrene	5500000	12708.3	314600		4.03952E-05	**8750.0**	304150		2.87687E-05	**6090.0**	279565		2.17837E-05
Dibenzo (a,h) anthracene	3300000	31250.0	188760		0.000165554	**20625.0**	182490		0.00011302	**15217.4**	167739		9.07207E-05
Benzo (g,h,i) perylene	1600000	18541.7	91520		0.000202597	**12708.3**	88480		0.000143629	**8913.0**	81328		0.000109594
Indno (1,2,3-cd) pyrene	1600000	12083.3	91520		0.000132029	**8125.0**	88480		9.18287E-05	**5652.2**	81328		6.94985E-05
PCBs													
Arochlor 1242	53000000	2500.0	3031600		8.24647E-07	**3333.3**	2930900		1.13731E-06	**7391.3**	2693990		2.74363E-06
Arochlor 1248	53000000	1770.8	3031600		5.84126E-07	**1770.9**	2930900		6.042E-07	**1770.9**	2693990		6.57334E-07
Arochlor 1254	53000000	3437.5	3031600		1.13389E-06	**3437.5**	2930900		1.17285E-06	**3804.4**	2693990		1.41216E-06
Arochlor 1260	53000000	3437.5	3031600		1.13389E-06	**3437.5**	2930900		1.17285E-06	**3804.4**	2693990		1.41216E-06
Arochlor 1016	53000000	1770.8	3031600		5.84126E-07	**1770.9**	2930900		6.042E-07	**1770.9**	2693990		6.57334E-07
Arochlor 1221	53000000	1770.8	3031600		5.84126E-07	**1770.9**	2930900		6.042E-07	**1770.9**	2693990		6.57334E-07
Arochlor 1232	53000000	1770.8	3031600		5.84126E-07	**1770.9**	2930900		6.042E-07	**1770.9**	2693990		[illegible]
Metals													
Arsenic	NA												
Cadmium	NA												
Chromium	NA												
Copper	NA												
Lead	NA												
Mercury	NA												
Nickel	NA												
Selenium	NA												
Zinc	NA												

		WSW 8-A+B				WSW 11-A+B				WSW 12-A+B			
Compound	Koc (ml/g)	(ppb)	Kd, bs	OCsed	Cw (mg/L)	(ppb)	Kdbs		Cw (mg/L)	(ppb)	Kd, bs	OCsed	Cw (mg/L)
PAHs				0.0508				TOC				0.0448	
Naphthalene	9.40E+02	5652.2	47.7755		0.118306955	5567.9	43.24	0.046	0.12876801	6843.3	42.112		1.63E-01
Acenapthylene	2.50E+03	5869.6	127.063		0.046194315	1403.1	115		0.012201026	5518.8	112		4.93E 02
Acenaphthene	4.50E+03	5869.6	228.713		0.025663508	5902.0	207		0.028512099	5739.5	201.6		2.85E-02
Fluorene	7.30E+03	2065.2	371.023		0.005566286	3563.5	335.8		0.010611895	39735.1	327.04		1.21E-01
Phenanthrene	1.40E+04	9173.9	711.55		0.012892858	24498.9	644		0.038041749	220750.6	627.2		3.52E-01
Anthracene	1.40E+04	3913.0	711.55		0.005499323	9799.6	644		0.0152167	88300.2	627.2		1.41E-01
Fluoranthane	3.80E+04	28260.9	1931.35		0.014632702	64588.0	1748		0.036949641	286975.7	1702.4		1.69E-01
Pyrene	3.80E+04	15000.0	1931.35		0.007766588	31180.4	1748		0.017837758	132450.3	1702.4		7.78E-02
Chrysene	2.00E+05	10000.0	10165		0.000983768	22271.7	9200		0.002420839	86092.7	8960		9.61E-03
Benzo (a) anthracene	1.38E+06	6521.7	70138.5		9.29837E-05	13140.3	63480		0.000206999	52980.1	61824		8.57E-04
Benzo (b) fluoranthene	5.50E+05	6736.1	27953.8		0.000240974	12472.2	25300		0.000492971	50772.6	24640		2.06E-03
Benzo (k) fluoranthene	5.50E+05	3260.9	27953.8		0.000116652	5567.9	25300		0.000220076	20971.3	24640		8.51E-04
Benzo (a) pyrene	5.50E+06	6521.7	279538		2.33305E-05	11804.0	253000		4.66562E-05	50772.6	246400		2.06E-04
Dibenzo (a,h) anthracene	3.30E+06	3587.0	167723		2.13863E-05	24498.9	151800		0.000161389	112582.8	147840		7.62E-04
Benzo (g,h,i) perylene	1.60E+06	7391.3	81320		9.08916E-05	14699.3	73600		0.000199719	59602.6	71680		8.32E-04
Indno (1,2,3-cd) pyrene	1.60E+06	5652.2	81320		6.95053E-05	10245.0	73600		0.000139198	41942.6	71680		5.85E-04
PCBs													
Arochlor 1242	5.30E+07	7826.1	2693725		2.9053E-06	8908.7	2438000		3.6541E-06	7947.0	2374400		3.34E-06
Arochlor 1248	5.30E+07	1847.9	2693725		6.85983E-07	1808.5	2438000		7.41801E-07	1770.8	2374400		7.46E-07
Arochlor 1254	5.30E+07	3804.4	2693725		1.4123E-06	3786.2	2438000		1.55299E-06	3624.4	2374400		1.53E-06
Arochlor 1260	5.30E+07	3804.4	2693725		1.4123E-06	3786.2	2438000		1.55299E-06	3642.4	2374400		1.53E-06
Arochlor 1016	5.30E+07	1847.9	2693725		6.85983E-07	1808.5	2438000		7.41801E-07	1770.8	2374400		7.46E-07
Arochlor 1221	5.30E+07	1847.9	2693725		6.85983E-07	1808.5	2438000		7.41801E-07	1770.8	2374400		7.46E-07
Arochlor 1232	5.30E+07	1847.9	2693725		6.85983E-07	1808.5	2438000		7.41801E-07	1770.8	2374400		7.46E-07
Metals													
Arsenic	NA												
Cadmium	NA												
Chromium	NA												
Copper	NA												
Lead	NA												
Mercury	NA												
Nickel	NA												
Selenium	NA												
Zinc	NA												

	USFWS North Slip					
	West End		Middle Section		East End	
Compound	1	2	3	4	9	10
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	65.396	75.342	34.344	0.868	42.995	39.567
Acenapthylene	9.117	10.482	5.261	0.870	0.817	6.048
Acenaphthene	5.065	4.879	0.385	1.038	2.221	0.371
Fluorene	2.271	2.619	1.310	0.867	1.548	1.511
Phenanthrene	4.243	5.565	2.605	0.762	3.415	3.416
Anthracene	1.727	1.037	0.982	1.665	1.304	0.590
Fluoranthane	1.999	0.578	0.046	3.461	1.487	0.013
Pyrene	4.181	0.578	0.046	7.236	3.088	0.006
Chrysene	0.449	0.602	0.009	0.746	0.369	0.012
Benzo (a) anthracene	0.031	0.034	0.018	0.916	0.022	0.019
Benzo (b) fluoranthene	0.075	0.098	0.001	0.770	0.051	0.001
Benzo (k) fluoranthene	0.049	0.026	0.001	1.902	0.033	0.001
Benzo (a) pyrene	0.008	0.003	0.005	2.419	0.006	0.002
Dibenzo (a,h) anthracene	0.029	0.021	0.000	1.379	0.013	0.000
Benzo (g,h,i) perylene	0.020	0.019	0.002	1.020	0.038	0.001
Indno (1,2,3-cd) pyrene	0.029	0.035	0.016	0.838	0.021	0.019
SPAHs						
PCBs						
Arochlor 1242	0.001	0.001	0.001	0.000	0.001	0.001
Arochlor 1248	0.001	0.001	0.001	0.001	0.001	0.001
Arochlor 1254	0.001	0.000	0.000	0.000	0.001	0.001
Arochlor 1260	0.003	0.003	0.002	0.001	0.001	0.001
Arochlor 1016	0.001	0.001	0.001	0.001	0.001	0.001
Arochlor 1221	0.001	0.001	0.001	0.001	0.001	0.001
Arochlor 1232	0.001	0.001	0.001	0.001	0.001	0.001
SPCBs						
Metals						
Arsenic	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA

alculated Aqueous
oncentrations of PAHs and
CBs using *Equilibrium*
artitioning Model.

	USFWS South Slip					
	West End		Middle Section		East End	
Compound	5	6	7	8	11	12
PAHs	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)	(ppb)
Naphthalene	619.947	440.858	145.594	118.307	128.768	162.502
Acenapthylene	37.879	11.754	46.190	46.194	12.201	49.275
Acenaphthene	21.044	21.767	25.661	25.664	28.512	28.470
Fluorene	12.473	9.289	6.445	5.566	10.612	121.499
Phenanthrene	28.617	19.913	14.358	12.893	38.042	351.962
Anthracene	11.187	8.342	6.415	5.499	15.217	140.785
Fluoranthane	25.879	17.845	14.631	14.633	36.950	168.571
Pyrene	14.377	9.617	8.103	7.767	17.838	77.802
Chrysene	2.003	1.281	0.941	0.984	2.421	9.609
Benzo (a) anthracene	0.164	0.112	0.090	0.093	0.207	0.857
Benzo (b) fluoranthene	0.437	0.301	0.233	0.241	0.493	2.061
Benzo (k) fluoranthene	0.192	0.130	0.117	0.117	0.220	0.851
Benzo (a) pyrene	0.040	0.029	0.022	0.023	0.047	0.206
Dibenzo (a,h) anthracene	0.166	0.113	0.091	0.021	0.161	0.762
Benzo (g,h,i) perylene	0.203	0.144	0.110	0.091	0.200	0.832
Indno (1,2,3-cd) pyrene	0.132	0.092	0.069	0.070	0.139	0.585
SPAHs						
PCBs						
Arochlor 1242	0.001	0.001	0.003	0.003	0.004	0.003
Arochlor 1248	0.001	0.001	0.001	0.001	0.001	0.001
Arochlor 1254	0.001	0.001	0.001	0.001	0.002	0.002
Arochlor 1260	0.001	0.001	0.001	0.001	0.002	0.002
Arochlor 1016	0.001	0.001	0.001	0.001	0.001	0.001
Arochlor 1221	0.001	0.001	0.001	0.001	0.001	0.001
Arochlor 1232	0.001	0.001	0.001	0.001	0.001	0.001
SPCBs						
Metals						
Arsenic	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	NA

APPENDIX I

PCs for WSW site's Contaminants of Concern (COCs)
Calculations for noncarcinogenic risks from ingestion of contaminated fish
Calculations for carcinogenic and noncarcinogenic risks from dermal contact with surface waters

Chemical	PC (cm/hr)
Chloroform	NA
Copper	3.16E-04
Lead	NA
Nickel	3.16E-04
Selenium	NA
Zinc	3.16E-04
Chromium VI	NA
Aluminium	NA
Arsenic	3.16E-04
Barium	3.16E-04
Cadmium	NA
Calcium	NA
Iron	NA
Magnesium	NA
Manganese	3.16E-04
Potassium	NA
Sodium	3.16E-04

hemical-specific PCs
'ermeability Constants) for
alculations of carcinogenic
ıd noncarcinogenic risks
om dermal exposure to
ırface waters

Contaminant	EPC (ppm)	$IR_{average}$ (g/d)	IR_{max} (g/d)	$FI_{average}$	FI_{max}	EF (d/yr)	$ED_{average}$ (yrs)	ED_{max} (yrs)	BW (kg)	$AT_{average}$ (d)	AT_{max} (d)	CDI_{min} (mg/kg/d)	CDI_{max} (mg/kg/d)	R_fD	$HQ_{average}$	HQ_{max}
PCB 1248	0.57	6.5	54	0.1	0.25	350	9	30	70	3285	10950	5.075E-05	0.00042	-	-	-
Chromium VI	8.3	6.5	54	0.1	0.25	350	9	30	70	3285	10950	7.390E-04	0.00614	0.003	0.0246	0.512
Copper	6.4	6.5	54	0.1	0.25	350	9	30	70	3285	10950	5.699E-04	0.00473	-	-	-
Lead	2.2	6.5	54	0.1	0.25	350	9	30	70	3285	10950	1.959E-04	0.00163	-	-	-
Nickel	4.7	6.5	54	0.1	0.25	350	9	30	70	3285	10950	4.185E-04	0.00348	0.02	0.0021	0.0435
Zinc	150	6.5	54	0.1	0.25	350	9	30	70	3285	10950	1.336E-02	0.11096	0.3	0.0045	[illegible]
														Hazard Index	0.0312	[illegible]

Contaminant	EPC (ppm)	$IR_{average}$ (g/d)	IR_{max} (g/d)	FI	FI	EF (d/yr)	$ED_{average}$ (yrs)	ED_{max} (yrs)	BW (kg)	AT_{avg} (days)	AT_{max} (days)	$CDI_{average}$ (mg/kg/d)	CDI_{max} (mg/kg/d)	R_fD	$HQ_{average}$ w/ FI	[illegible] w/ FI
PCB 1248	0.9	6.5	54	0.1	0.25	350	9	30	70	3285	10950	8.0137E-05	0.0006658	-	-	-
Fluoranthene	0.046	6.5	54	0.1	0.25	350	9	30	70	3285	10950	4.10E-06	0.000034	0.04	1.02E-05	[illegible]
Pyrene	0.038	6.5	54	0.1	0.25	350	9	30	70	3285	10950	3.38E-06	0.000028	0.03	1.13E-05	[illegible]
Copper	23.5	6.5	54	0.1	0.25	350	9	30	70	3285	10950	2.09E-03	0.017384	-	-	-
Lead	2.7	6.5	54	0.1	0.25	350	9	30	70	3285	10950	2.40E-04	0.001997	-	-	
Nickel	4.8	6.5	54	0.1	0.25	350	9	30	70	3285	10950	4.27E-04	0.003551	0.02	2.14E-03	[illegible]
Selenium	2.4	6.5	54	0.1	0.25	350	9	30	70	3285	10950	2.14E-04	0.001775	0.005	4.27E-03	[illegible]
Zinc	110	6.5	54	0.1	0.25	350	9	30	70	3285	10950	9.79E-03	0.081370	0.3	3.26E-03	[illegible]
														Hazard Index	9.70E-03	[illegible]

Contaminant	EPC (ppm)	$IR_{average}$ (g/day)	IR_{max} (g/day)	$FI_{average}$	FI_{max}	EF (d/yr)	$ED_{average}$ (yrs)	ED_{max} (yrs)	BW (kg)	$AT_{average}$ (d)	AT_{max} (d)	CDI_{min} (mg/kg/d)	CDI_{max} (mg/kg/d)	R_fD	$HQ_{average}$	HQ_{max}
PCB 1248	1	6.5	54	0.1	0.25	350	9	30	70	3285	10950	8.90E-05	0.000740	-		
Chromium VI	2	6.5	54	0.1	0.25	350	9	30	70	3285	10950	1.78E-04	0.001479	0.003	0.006	[illegible]
Copper	8.9	6.5	54	0.1	0.25	350	9	30	70	3285	10950	7.92E-04	0.006584	-	-	-
Lead	0.64	6.5	54	0.1	0.25	350	9	30	70	3285	10950	5.70E-05	0.000473	-	-	
Nickel	5.2	6.5	54	0.1	0.25	350	9	30	70	3285	10950	4.63E-04	0.003847	0.02	0.002	0.048
Zinc	131	6.5	54	0.1	0.25	350	9	30	70	3285	10950	1.17E-02	0.096904	0.3	0.004	[illegible]
														Hazard Index	[illegible]	[illegible]

Contaminant	CW mg/L	$SA_{average}$ cm^2	SA_{max} cm^2	PC cm/hr	ET hr/day	$EF_{average}$ days/yr	EF_{max} days/yr	$ED_{average}$ years	ED_{max} years	CF 1 L/cm^3	BW kg	$AT_{average}$ days	AT_{max} days	$AD_{average}$ mg/kg/day	AD_{max} mg/kg/day	R_fD	$HQ_{average}$	HQ_{max}
Chloroform	3	1740	4820		1	40	60	9	30	0.001	70	3285	10950			-		
Aluminium	283	1740	4820													4.00E-04		
Arsenic	0.675	1740	4820	3.16E-04	1	40	60	9	30	0.001	70	3285	10950	7.47057E-08	1.03472E-06	3.00E-04	2.49E-04	3.45E-03
Barium	25.5	1740	4820	3.16E-04	1	40	60	9	30	0.001	70	3285	10950	2.82221E-06	3.90893E-05	7.00E-02	4.03E-05	5.58E-04
Cadmium	2.58	1740	4820													5.00E-04		
Calcium	41000	1740	4820													4.00E-02		
Copper	4.63	1740	4820	3.16E-04	1	40	60	9	30	0.001	70	3285	10950	5.12426E-07	7.09739E-06	-		
Iron	320	1740	4820													-		
Lead	5.8	1740	4820													-		
Magnesium	9900	1740	4820													-		
Manganese	34.5	1740	4820	3.16E-04	1	40	60	9	30	0.001	70	3285	10950	3.81829E-06	5.28855E-05	1.40E-01	2.72735E-05	3.78E-04
Nickel	14.05	1740	4820	3.16E-04	1	40	60	9	30	0.001	70	3285	10950	1.55499E-06	2.15374E-05	2.00E-02	7.77493E-05	1.08E-03
Potassium	2927.5	1740	4820													5.00E-02		
Sodium	37875	1740	4820													4.00E-02		
Zinc	9.53	1740	4820	3.16E-04	1	40	60	9	30	0.001	70	3285	10950	1.05473E-06	1.46087E-05	3.00E-01	3.52E-06	4.87E-05
																Hazard Index	3.98E-04	5.51E-03

Contaminant	CW	$SA_{average}$	SA_{max}	PC	ET	$EF_{average}$	EF_{max}	$ED_{average}$	ED_{max}	CF	BW	$AT_{average}$	AT_{max}	$AD_{average}$	AD_{max}	R_fD	$HQ_{average}$	HQ_{max}
	mg/L	cm^2	cm^2	cm/hr	hr/day	days/yr	days/yr	years	years	1 L/cm^3	kg	days	days	mg/kg/day	mg/kg/day			
Chloroform	3	1740	4820	-	1	40	60	9	30	0.001	70	3285	10950			-		
Benzene	8	1740	4820	-	1	40	60	9	30	0.001	70	3285	10950					
Toluene	5	1740	4820	-	1	40	60	9	30	0.001	70	3285	10950					
Aluminium	614	1740	4820													0.0004		
Arsenic	1.5	1740	4820	0.000316	1	40	60	9	30	0.001	70	3285	10950	1.66013E-07	2.29937E-06	0.0003	0.000553375	0.007664568
Barium	27.45	1740	4820	0.000316	1	40	60	9	30	0.001	70	3285	10950	3.03803E-06	4.20785E-05	0.07	4.34004E-05	0.000601121
Calcium	40150	1740	4820													0.04		
Iron	622	1740	4820													-		
Lead	4.05	1740	4820													-		
Magnesium	11950	1740	4820													-		
Manganese	48.55	1740	4820	0.000316	1	40	60	9	30	0.001	70	3285	10950	5.37328E-06	7.4423E-05	0.14	3.83805E-05	0.000531593
Nickel	7	1740	4820	0.000316	1	40	60	9	30	0.001	70	3285	10950	7.74726E-07	1.07304E-05	0.02	3.87363E-05	0.00053652
Potassium	2585	1740	4820													0.05		
Sodium	37200	1740	4820													0.04		
Zinc	14.15	1740	4820	0.000316	1	40	60	9	30	0.001	70	3285	10950	1.56605E-06	2.16907E-05	0.3	5.22018E-06	7.23024E-05
																Hazard Index	0.000679113	0.009406104